BULLETIN No. 26.

U. S. DEPARTMENT OF AGRICULTURE,

DIVISION OF BOTANY.

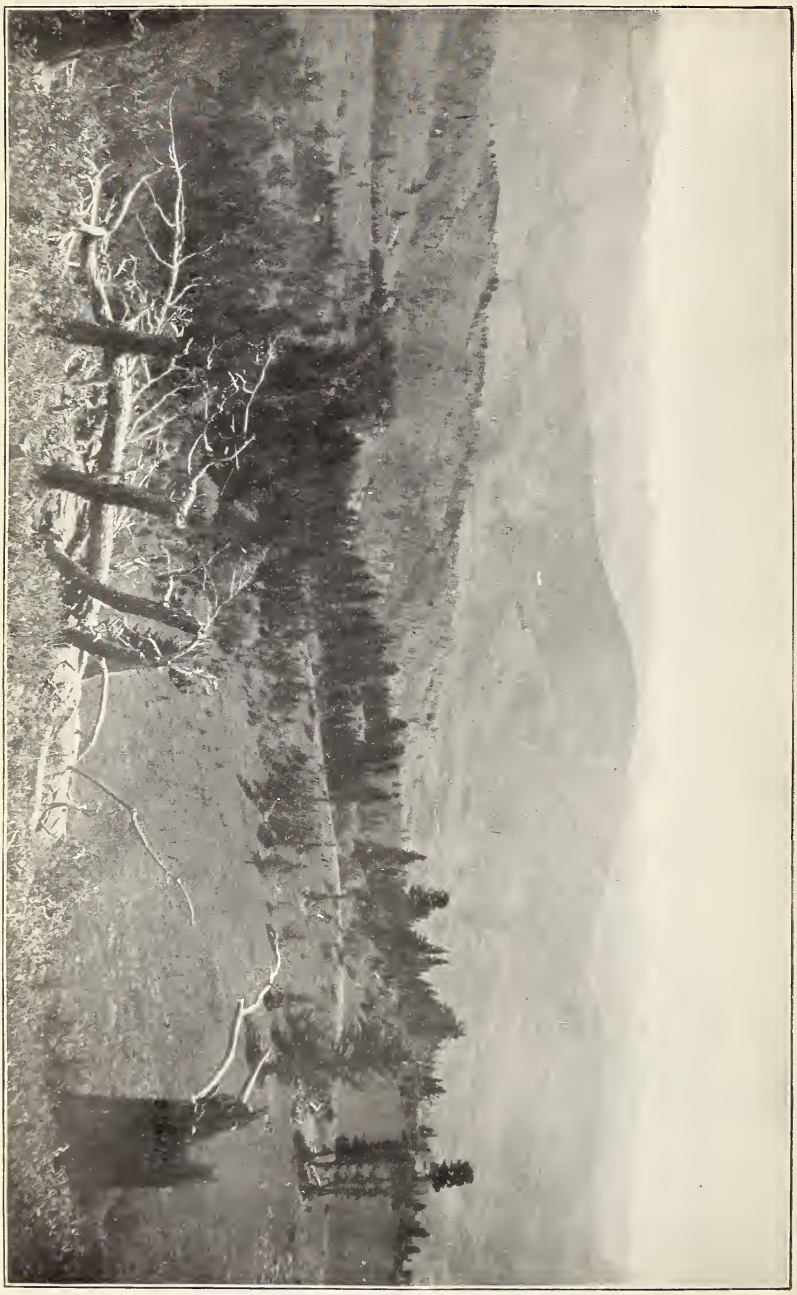
THE STOCK-POISONING PLANTS OF MONTANA:

A PRELIMINARY REPORT

BY

V. K. CHESNUT AND E. V. WILCOX.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1901.



A TYPICAL MOUNTAIN STOCK RANGE. FROM BRIDGER PEAK, LOOKING EAST.

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To the Senate and House of Representatives:

I transmit herewith for the information of the Congress a communication from the Secretary of Agriculture recommending the printing of the accompanying report on The Stock-Poisoning Plants of Montana.

WILLIAM MCKINLEY.

EXECUTIVE MANSION,
February 12, 1901.

U. S. Department of Agriculture,
Office of the Secretary,
Washington, D. C., February 9, 1901.

Mr. President: I have the honor to transmit a preliminary report on the poisonous plants of the stock ranges of Montana. This report is the result of an investigation undertaken by the Department of Agriculture at the request of the State board of sheep commissioners. It has an important bearing on the stock interests of Montana and adjacent States, containing as it does not only a detailed account of the investigations and experiments, but concise summaries of symptoms, treatment, and remedies, which bring the results of the discoveries to the point of practical application by stock owners. A report of this character, which makes possible the saving of heavy annual losses to a great industry, should be widely distributed among the people who can profit by it. Under existing statute only a thousand copies could be printed by this Department, and I have the honor to recommend, therefore, that the report be transmitted to Congress, and that attention be called to the desirability of printing an edition sufficient to permit at least five thousand copies to be distributed by the Department of Agriculture.

I have the honor to remain, Mr. President,
Very respectfully,

James Wilson,
Secretary.

LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Division of Botany,
Washington, D. C., February 9, 1901.

Sir: I have the honor to transmit herewith for your consideration a manuscript entitled "The Stock-Poisoning Plants of Montana: A Preliminary Report," by Mr. V. K. Chesnut, assistant in charge of investigations of poisonous plants, and Dr. E. V. Wilcox, assistant in the Office of Experiment Stations.

The State veterinarian of Montana, Dr. M. E. Knowles, in his annual report to the State board of sheep commissioners for the year 1899, made the following statement:

> Poisonous plants every year in this State are responsible for much loss in sheep, and it is to be hoped that your honorable body will use your influence with the Department of Agriculture to have the localities in our State, where these plants exist, mapped out, and, if possible, a description of all the known poisonous plants published in such language that the layman may understand, and it would be well, even, to have cuts made of each plant.

Hon. T. C. Power, president of the board, laid the matter before you, citing the large losses of live stock in Montana, both cattle and horses as well as sheep, which were supposed to be due to poisonous plants, and secured your approval of the investigation. The cooperation of the Montana agricultural experiment station was secured, and Mr. Chesnut and Dr. Wilcox, the latter temporarily transferred to the Division of Botany through the courtesy of Dr. A. C. True, Director of the Office of Experiment Stations, were detailed to field work on the 1st of May, with suitable instructions. The accompanying manuscript is the report of their investigations in the season of 1900.

Respectfully,

Frederick V. Coville,
Botanist.

Hon. James Wilson,
Secretary of Agriculture.

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STOCK-POISONING PLANTS OF MONTANA.

GENERAL INTRODUCTION.

STOCK INDUSTRY OF MONTANA.

Montana is a typical grazing State. Long before it was so closely connected by its two great railway systems, the Northern Pacific and Great Northern, with the more settled regions to the east and west, its wide open ranges were a favorite ground for hunting herbivorous animals. Immense herds of elk, deer, and buffalo then roved over its grassy plains and mountain sides. These animals have gradually been almost wholly exterminated from the State, and now in their place there are hundreds of thousands of horses, cattle, and sheep, which are being bred or fattened by their owners for profit, advantage being taken of the permitted free use of the large areas of public domain which the State still contains.

The enormous growth of the stock industry of the State may be illustrated from the comparative statistics for sheep, the data for which have, perhaps, been most accurately secured in the different States. According to the census of 1880, the States which held the largest number of sheep were in their order, Iowa, Illinois, Ohio, and Missouri. The sheep were for the most part kept on farms. The aggregate number on farms was about 35,000,000, the number ranging on the public domain was approximately 7,000,000, and those otherwise held numbered 3,000,000, making a total of over 45,000,000. On July 1, 1900, the total aggregate number of sheep in the United States was reported by the Division of Statistics of the Department of Agriculture to be nearly 42,000,000. The States which then contained the largest holdings were in the order of their numbers, New Mexico and Montana, each with nearly 4,000,000; Wyoming and Ohio, each with nearly 3,000,000; and, with holdings of over 2,000,000 each, Idaho, Oregon, Texas, Utah, Colorado, and California. New Mexico, although the leading State in the number of sheep possessed, ranked only fourth with respect to money value. Montana, the second State, with regard to numbers, ranked first as to value, the total holdings amounting to a little over $11,000,000. The holdings in Ohio aggregated about $10,500,000, and New Mexico about $8,500,000. Oregon,

Idaho, Utah, Colorado, and California, each held over $5,000,000 worth of sheep. The total value of these sheep throughout the United States on January 1, 1900, was estimated to be $122,665,913. At as recent a date as 1870 there were, according to the third annual report of the board of sheep commissioners of Montana, for 1899, but 4,212 sheep in the State. In 1880 there were 249,978. In 1890 the number had increased to 1,555,116, and now it is about 4,000,000.

OCCASION AND AIDS OF THE PRESENT INVESTIGATION.

Notwithstanding the great advantages of which the stock-raising industry of the State can boast, it has to contend with a few drawbacks. Two of these come within the domain of botany and agriculture. They are, first, the existence on the feeding grounds of great quantities of certain poisonous plants which, as the table given on page 34 will show, are sometimes eaten extensively with fatal effect; and, second, the difficulty of producing sufficient hay to keep the animals in good condition over winter. The latter difficulty has recently been considered by Prof. Robert S. Shaw in Bulletin 21 of the Montana experiment station. The former has already been considered to a certain extent by one of us, Dr. E. V. Wilcox, in Bulletins 15 and 22 of the same station.

Much attention has also been and is still being given to the subject; especially from the chemical standpoint, by Dr. F. W. Traphagen, chemist of the Montana station, and by his assistants; and from the veterinary standpoint by Dr. M. E. Knowles, of Helena, the State veterinarian, and his associates.

This report gives the results of a short preliminary investigation which was inaugurated at the urgent solicitation of the State board of sheep commissioners of Montana and warmly seconded by the State experiment station as well as by individual stockmen throughout the State. It is a pleasure for us to refer with thankful appreciation to the hearty cooperation which was given us by the various members of the station staff, including especially Director S. M. Emery, Prof. F. W. Traphagen, Prof. J. W. Blankinship, Prof. Robert S. Shaw, and Prof. W. M. Cobleigh. To the last we are indebted for all but two or three of the photographs reproduced in this report. Professor Traphagen and Professor Blankinship not only gave us the free use of their libraries and laboratories, but also furnished us with material and their personal assistance as well as many valuable suggestions. To Dr. P. A. Rydberg, of the New York Botanical Garden, we are indebted for the final identification of the plants noted in the report.

It is especially pleasing to refer to the generous assistance which was received from the stockmen. Hon. T. C. Power took every occasion to notify them of our presence in the State and to request reports from them concerning any case of possible poisoning. Many letters of

introduction were furnished by this gentleman, and also by Dr. M. E. Knowles, which rendered possible a rapid and satisfactory survey of the conditions in different parts of the State. It would have been impossible to see in the time at our disposal so much of the range country of Montana without the generous assistance of these gentlemen, and of Messrs. S. M. Emery and Cornelius Hedges. In all parts of the State stockmen gladly accompanied us in studying the actual conditions where poisoning had taken place, or, where it was impossible for ranch owners to go on such trips, conveyances were freely furnished for our use. In a number of instances the stockmen were sufficiently interested to be willing to furnish sheep for feeding experiments with poisonous plants. Among these stockmen to whom we are especially indebted in the ways just indicated mention may be made of the following: W. W. Beasley, G. M. Beasley, A. E. Bower, G. C. Bower, F. I. Bower, Frank Conely, Walter Cooper, G. P. Christian, P. B. Christian, Daniel Floweree, W. C. Gillette, L. H. Hamilton, Dr. H. Holloway, S. S. Hobson, Edward A. Kimpton, C. Kohrs, J. B. Long, M. M. Jenson, J. L. B. Mayer, J. T. Murphy, I. D. O'Donnell, C. H. Perrine, McC. Winiger, F. Pool, B. E. Stack, James Vestal, F. Warren, J. F. Woolman, and Mr. Warden of Augusta.

ITINERARY.

In the course of our investigations of the stock-poisoning plants of Montana we visited every county of the State, both of the mountains and the plains. The greater part of the time, however, was spent in Fergus, Cascade, Teton, Park, Sweet Grass, and Yellowstone counties. The distance covered by the different trips in the field aggregated something more than 7,000 miles. Along the line of the Northern Pacific Railroad the following localities were visited: Wibaux, Glendive, Miles City, Forsyth, Huntley, Billings, Laurel, Joliet, Red Lodge, Greycliff, Bigtimber, Livingston, Coalspur, Muir, Chesnut, Bozeman, Belgrade, Logan, Townsend, Helena, Garrison, Deerlodge, Drummond, Bearmouth, Missoula, and Plains; along the course of the Montana Railroad: Merino, Martinsdale, Dorsey, Lombard; on the line of the Great Northern Railway: Glasgow, Havre, Shelby Junction, Baltic, Cutbank, Summit, Columbia Falls, Kalispell, Fort Benton, Great Falls, Cascade, and Craig. From each of these points drives or horseback trips of from 10 to 150 miles were made into the surrounding country. From Great Falls a trip was made across country through Belt, Geyser, Stanford, Utica, Ubet, Oka, Hopley, and Martinsdale. From Craig a trip was made by means of stage and private conveyance to Augusta and the mountain ranges lying between the forks of the Sun River. These trips by wagon or horseback occupied from 1 to 15 days each and rendered possible a

thorough inspection of the general range conditions in those parts of the State which are best adapted to stock raising. In general, the most thorough study was made of ranges where serious losses of stock had occurred during the season of 1900 or previous seasons, especially where the stockmen manifested a lively interest in the investigation and requested a visit to their ranges. Numerous requests were received by letter or telegram to make such visits, and all such requests were heeded if time permitted, for the reason that it was considered highly desirable to see as many cases as possible under natural conditions and thus to be able to note the symptoms of poisoning and the special circumstances of each case. The stockmen took such interest in making prompt notifications of cases of poisoning that many exceptional opportunities were had for observing cattle, horses, and sheep poisoned by different plants. In some cases it was impossible to reach the locality in time to observe the early symptoms, but in a majority of the cases which are recorded in this report the symptoms and circumstances of poisoning were studied in the field at first hand.

GENERAL RANGE CONDITIONS.

SUMMER AND WINTER RANGES FOR SHEEP.

The majority of sheep raisers in the State are so situated that a part of their range is of the nature of treeless prairie while another part lies on the foothills or lower slopes of the mountains. Frequently the different tracts of range belonging to a single sheep raiser are not contiguous and it is therefore necessary to drive the sheep for short distances in order to move them from one range to another. The prevailing practice of sheep men is so to manage the grazing of the sheep upon the range that the sheep will be able to find the best possible pasture during the greater part of the year. In the early days of stock raising in the State the sheep men did not, as a rule, provide forage in the form of hay for the inclement weather of winter, but were apparently willing to take chances with their sheep under such climatic conditions as might develop. It was evidently of prime importance in this system of management that a portion of the range be reserved in good condition for winter grazing.

During recent years the sheep men of the State have realized more and more fully the importance of cutting large quantities of hay for feeding during the time when the ground may be covered with snow. The same custom still prevails, however, of dividing the range into a summer and winter range. As a general rule the ewe bands are held near the home ranch during the lambing season and until after shearing, when all the sheep are taken to the foothills or mountain ranges. It may be said, therefore, that sheep are held on the open prairie ranges during the winter and spring, while the mountain ranges

are utilized from July until October. Several reasons may be urged for this system of management. In the first place, it is most convenient to have the ewes near home during the period of lambing, since they require constant attention at this time. The shearing season falls almost immediately after that of lambing, and it is obviously desirable that the wool should be removed at the points which are most convenient for transporting it to the railroad. A third reason, which is not less important, is the fact, which has been demonstrated by repeated experiments, that the foothill or mountain ranges are much more dangerous from the standpoint of poisonous plants during the early wet season than during the latter part of the summer and fall. Sheep men have known for several years that it is relatively or entirely safe to keep sheep on mountain ranges after the middle of July on which large numbers of sheep would almost certainly be poisoned if allowed to graze there during the months of May and June. It is a fact generally observed by stockmen, and especially apparent to an observer in traveling over different parts of the State, that the range becomes freer and freer from plants of all description, except grasses, the farther one goes from the mountains. In the open prairie country, at a distance of 20 miles from the foothills or mountains, there are thousands of acres of good grazing country where almost no vegetation except grass is to be found. The grass upon the clean prairie range is, for the most part, short, and it is well known that short grass is preferred by sheep to tall grass, which, under ordinary circumstances, they avoid. This observed fact is strikingly illustrated in the different feeding habits of sheep on prairie ranges and on mountain ranges. On the former, sheep, as just indicated, seem decidedly to prefer short grass and such other plants as may in their early vegetative stages resemble grass, as, for instance, the species of Zygadenus. Other plants of a coarser nature are almost uniformly avoided on a prairie range during the greater part of the season. When, on the other hand, sheep are taken to the mountain range during July they avoid, for the most part, the tall grass growing in such localities and feed upon other plants, such as Balsamorhiza, Lepachys, Solidago, Potentilla, Spiraea, Astragalus, Glycyrrhiza, Lupinus, Geranium, etc.

The difficulties which lie in the way of grazing sheep and cattle together on a prairie range partly disappear on the mountain ranges from the fact that the sheep and cattle do not there eat the same kinds of plants, the cattle preferring grass and the sheep the class of plants which have just been instanced. The majority of plants known to be poisonous and which are especially dangerous during the wet months of May and June are so far advanced by the time the sheep are taken to the mountain ranges that they are not tempting and are not eaten. The smaller species of larkspur (*Delphinium bicolor*) and death camas

(*Zygadenus venenosus*) are so dry and shriveled by the middle of July that they are absolutely unpalatable to any animal. The water hemlock (*Cicuta occidentalis*) does not grow so abundantly in the mountains as along the small streams and irrigation ditches of the plains, and becomes so large and coarse by the time mentioned that it is scarcely ever, if at all, eaten by sheep. The tall larkspur (*D. glaucum*), so far as our observations go, does not grow on the plains in any part of Montana, and is too coarse to be eaten by sheep during the season from July to October. The sheep owners have found by experience that these mountain ranges which are so extremely dangerous for sheep during the early summer are quite safe during the months from July to September, inclusive.

The safety of the mountain ranges, however, is somewhat affected by the presence of species of lupines. These plants are poisonous during certain stages, especially when containing ripe seeds. It is of interest to observe that sheep seldom eat lupine on the range during midsummer. If, however, they do eat it at a time when the seeds are ripe, it invariably causes disastrous poisoning. After the early fall frosts the pods of this plant rapidly open and the seeds fall out upon the ground. After this period it seems that the plants may be eaten with impunity by sheep or other animals. Occasionally, however, the seeds are retained in considerable numbers in the pods until October or even November. A number of serious losses of sheep have been due to eating lupines in this condition after early fall snowstorms have covered the other forms of vegetation on the range. On account of the fact that cattle and horses are for the most part allowed to run freely upon the open range, the distinction between the summer and winter range in the case of these animals is not so important as in the case of sheep. Many cattlemen take advantage of the fall and spring round-ups to direct their cattle and horses to a range near the home ranch in winter and farther away in summer. The fact that horses and cattle are not herded like sheep prevents any arrangement such as that already mentioned as being commonly adopted in the management of sheep.

EFFECT OF ALKALI ON STOCK.

A considerable difference of opinion prevails among stock raisers as to the physiological effect of alkali upon stock. A number of them still insist that the ordinary alkali found in the soil or around the borders of alkali lakes is a complete and perfect substitute for common salt. On the other hand an equally large and apparently increasing number of stockmen believe that alkali can under no conditions take the place of salt in the animal economy.

In discussing the loco problem, attention will be called to the possible influence of alkali in predisposing animals to the loco habit. In

this connection it may be well to note the possibility that the failure to provide salt for animals on the range may tend to produce a perverted or depraved appetite. Where salt is wanting it is quite possible that stock more readily eat various noxious plants than when they are receiving salt regularly in suitable quantities.

In the absence of any direct experiments on this question, it would seem safe to assume on general principles that the common forms of alkali found in the State have no physiological effects which compare with those of common salt. The forms of alkali which occur in the State are sulphate of soda, epsom salts, and carbonate of soda; and, as well known, the physiological effects of these substances differ decidedly from those of common salt.

Observations on this point can most easily be made on the sheep, since these animals are under constant attention. A number of sheep men have been led to believe that regular salting has a tendency to render sheep more docile and more easily managed; that the failure to give salt in sufficient quantity and at the right time tends to produce a nervous uneasiness in the sheep which manifests itself partly in the eating of undue quantities of soil containing alkali. As to any injurious effects which may be produced in stock by the eating of large amounts of alkali, no reliable observations have been made. It is believed by some sheep raisers that the eating of alkali earth may cause the so-called locoed condition of sheep, but no data are at hand to prove this assertion.

HERDING AND OTHER DETAILS OF THE MANAGEMENT OF SHEEP.

Attention has already been called to the fact that sheep have to be moved over considerable distances in changing from one range to another. Some of the most disastrous cases of poisoning among them have occurred during these drives. It requires but little observation to convince one that sheep when being driven hurriedly from place to place are apt to eat many plants which they would not eat if allowed to feed at leisure. When feeding quietly on the range they exercise considerable choice in the selection of forage plants, but when being driven from 6 to 10 miles a day they are frequently forced to bite off almost all kinds of plants which grow along their course. The writers have observed a number of striking illustrations of this fact at all seasons of the year. On May 24 a band of 2,000 ewes and lambs were driven a distance of about 3 miles. This band of sheep had been grazing for two weeks on a range where death camas was quite abundant, but no cases of poisoning had occurred up to this time. During the day a number of sheep were observed to eat the plant. Six ewes and 10 lambs died. About 20 ewes and 50 lambs were affected. Many other similar cases might be related, but the fact is well understood by sheep men that sheep are more likely to eat poisonous plants when

being driven rapidly and in a hungry condition than under conditions of rest and full stomach. Similar statements may be made concerning the trailing of sheep, a practice which prevails to a considerable extent among sheep men who are located at some distance from the railroad. In the early spring the sheep raiser selects those sheep which he wishes to sell and drives them to the nearest railroad or possibly a much longer distance toward some larger market. During the transit a much larger percentage of deaths occur from eating poisonous plants than would occur in the same band of sheep if allowed to feed on the range. The only reasons which have been suggested or which seem adequate to explain this condition have already been mentioned.

The ordinary practice of sheep raisers under the conditions which prevail upon the Western ranges is to keep the sheep under the constant attention of a herder. The size of the bands is generally from 2,000 to 2,500. This number of sheep has been adopted as being the largest which can be conveniently managed by one man, and also the largest which can conveniently spread out so far as to graze with ease. This method of managing sheep has certain disadvantages which become apparent upon close observation of their feeding habits. As is well known to sheep raisers, it requires a considerable length of time for a band of 2,500 to become widely enough scattered for grazing purposes after being let out of the corral in the morning or after being rounded up on the range. During this time the sheep which happen to be on the outside of the band have good opportunity to graze, while those which are crowded together in the center are utterly unable to feed until the outside sheep have moved away to some distance. Experienced herders interfere with the movements of the sheep just as little as is compatible with directing them over the desired course for the day. On the other hand it is a fact which all sheep raisers have observed that a considerable proportion of herders continually urge forward the sheep which are in the rear of the bands and drive in the stragglers with the aid of the dog in order to maintain as compact a herd as possible. This is certainly a wrong method of managing sheep. Whenever they are frightened by the dog or otherwise their habit is to crowd together in a compact mass, and they remain in this position for some time before again scattering over the range for grazing. The worry incident to this repeated dogging and otherwise frightening the sheep must be severe, aside from the consideration of the loss of grazing time.

But, desirable as it is to give the sheep the greatest possible freedom, under present range conditions in the West it is manifestly impossible to leave sheep to their own resources. The country is only partially fenced, and the greater part of the fences which are already built will not turn sheep. There is nothing, therefore, to prevent them, when not under the care of a herder, from wandering away to

indefinite distances. It must also be remembered that wolves and coyotes are still to be found in some numbers on sheep and cattle ranges, and an attack by these animals upon the sheep is sure to result in disastrous consequences. For the present, therefore, no other method of managing sheep would seem practicable than the one now in vogue. When wolves and coyotes shall have been exterminated in the locality of sheep ranges, and these ranges shall have been inclosed in sheep-tight fences, it will perhaps be possible to dispense with the constant attendance of herders. It is probable that the method of keeping sheep in comparatively small herds in inclosed areas and allowing them to feed without any interference will secure better results in wool and mutton production than are secured by the present method.

The realization of this change would relieve, moreover, another perplexing problem in the management of the sheep range, namely, to obtain efficient and reliable herders. From a business standpoint the sheep owner must be considered to take great risk when he places a band of sheep, valued at from $8,000 to $10,000, in the hands of a man whom he has perhaps not known for more than a week. Many of the herders are reliable and experienced, while unfortunately many others, either from lack of experience or from irresponsible conduct, cause the sheep owners great losses which could have been entirely avoided. A further possible disadvantage of the existing system is that the complete control and direction of the movements of the sheep by herders may tend in a series of generations to render the sheep more and more helpless and dependent on the protection and guidance of man. It is a common fact of observation that sheep which have been closely herded, if left to themselves, are at first completely helpless and unable to seek protection against storms and to find water supply. It would not seem unreasonable to suppose that if the method of managing sheep mentioned above should become possible in the western ranges, sheep would gradually acquire a knowledge of the range and an ability to care for themselves similar to that possessed by cattle and horses under the same conditions.

The present method of managing sheep possesses the advantage that when the herder knows by sight the poisonous plants of the range and is acquainted with their habitat and distribution he may easily herd the sheep away from the areas where such poisonous plants grow during the season when they are dangerous. On many sheep ranges certain areas have been found to be dangerous at certain times of the year, and the sheep are always kept away from these places during the dangerous season.

WATER SUPPLY ON THE RANGES.

The water supply on the stock ranges of Montana is abundant except during very dry years. Near the mountains and along the foothills numerous creeks and small streams are to be found, varying in size

according to the time of year and the amount of snow in the mountains. These small streams flow out over the plains and usually contain throughout their course a fairly uniform volume of water, but disappear at times where the bed is gravelly. A great number of springs are to be found in all situations near the mountains and on the plains, and on many ranges these springs furnish the water which is to be relied upon in the dry season. Besides the creeks and springs there are numerous lakes, some of them more or less alkaline, which furnish water for all kinds of stock. Many of the alkaline lakes are formed by the water from alkali springs. By the constant evaporation of these lakes the water becomes more strongly alkaline than is the water which flows into them from the springs. For this reason, and also on account of the fact that the borders of such lakes are muddy and difficult to approach, the plan of building troughs to receive the water directly from the springs has been adopted upon many sheep ranches. The water in the troughs is of course less strongly alkaline than is that in the lakes, and it is more easily accessible. This scheme for watering stock would seem highly commendable in view of the probable injurious effects of drinking large quantities of strongly alkaline water.

ALTITUDE OF THE RANGES.

The altitude of the stock ranges in Montana varies from about 1,900 to 9,000 feet. As already indicated, a large number of the stockmen of Montana have both prairie and mountain ranges. The prairie ranges average in altitude from 1,900 to about 5,000 feet. The lowest prairie range is found in the northeastern part of the State, in Valley and Dawson counties. Perhaps the highest range of this sort is found in the Smith River country. Cattle and horses during the summer and autumn occasionally range to the height of 8,000 to 9,000 feet, where in many parts of the State they find excellent pasture. As a rule, however, in Montana good range is not to be found above 7,000 feet. Along the slopes of the Rockies grass and other herbaceous vegetation have a definite and sharp limit, the upper two to four thousand feet of the mountains being rocky and without soil. It will be readily understood that cattle and horses, left as they are to their own resources and grazing in small herds, will find their way to higher and more inaccessible pastures than will sheep. With regard to the grazing of sheep in timber, it may be said that this is not practiced in Montana. As a rule there is no vegetation under trees which is desired by sheep, and it is exceedingly difficult to manage large bands of them in timber. On many mountain sides which are covered for the most part with forests there are large open parks in which good grazing is found, and such places are much coveted by sheep men for summer range. The sheep, however, will not of their own accord enter the

timber, and can only with difficulty be driven through it. Even for the usual noonday rest they uniformly prefer to lie in the open field exposed to the sun.

CLIMATIC CHARACTER OF THE SEASON OF 1900.

The season of 1900 in Montana was unusually early and unusually dry. During the previous winter the fall of snow was remarkably light, except for the unexpectedly severe storm of October, 1899. During the greater part of the winter there was no snow either on the mountains or on the plains. At the beginning of May vegetation was from two weeks to one month in advance of the average season. Over a considerable portion of the State, moreover, the rains which are expected during the months of May and June did not occur. As a result of this failure, the grasses and other plants of the range were checked in their growth and matured very rapidly. This condition of affairs prevailed generally over that part of the State which lies east of the mountains. In some localities westward heavy rainstorms occurred at intervals during May and June, but here practically no rain fell during these two months. This was especially true from Billings east along the line of the Northern Pacific Railroad, and from Havre east along the Great Northern Railroad. In this tract of country the range became so exceedingly dry that prairie fires occurred in several localities during the month of May. These fires assumed dangerous proportions, and a number of sheep were burned to death in them. In the vicinity of Wibaux the danger from prairie fires was increased by the fact that the grass had attained an unusual height during the preceding year and was still standing on the range in a dry condition. The grass of the present season did not offer sufficient green material to prevent the fire from spreading in the old grass. During the month of April the rainfall had been unusually large, and the ranges in consequence were in excellent condition at the beginning of May. It might naturally be supposed that with the grass in specially good condition sheep would be less likely to eat poisonous plants than during seasons when the grass was more backward. Such, however, was not the case. The early spring losses from poisonous plants were fully as serious during the season as they ordinarily are. During June and the first half of July an exceptionally large number of sheep were killed by eating poisonous plants, but this might have been reasonably expected from the fact that the ranges, as already indicated, had become largely dried up at this time. West of the Rocky Mountains, where an abundance of rain fell during the spring and early summer months, which was particularly the case in Flathead, Bitterroot, and Deerlodge valleys, some stock poisoning occurred in early spring, but very little during midsummer.

Such dry seasons as that of 1900 seem not to be so disastrous to the stock industry as might be expected. The short, dry grass produced

in such seasons is apparently more nutritious than the longer, softer grass of wet seasons, and stock keep in better condition when grazing on the short grass than when supplied with large quantities of the tall, soft grass. The chief fear of the stock grower in dry seasons is that he will not be able to cut sufficient quantities of hay for winter feeding.

CONDITIONS UNDER WHICH POISONING OCCURS.

INFLUENCE OF HEAVY RAINSTORMS.

Stockmen have observed for many years that during the spring months poisoning is apt to occur after heavy rains. This may be said to be a general belief of stock raisers and it is supported by numerous observations. Various explanations have been offered for this fact. It has been suggested that certain plants may be more poisonous when wet with fresh rain or dew than under other conditions, but there seems to be no ground for such a supposition. The explanation which is most frequently proposed for this phenomenon is that stock when feeding immediately after heavy rainstorms are more apt to pull up the roots of plants than when the range is dry. It is, of course, well known that in the case of many poisonous plants the active principle is located mostly in the roots and that large quantities of the leaves or stems would have to be eaten in order to cause serious poisoning. After a few days of dry weather the sod of prairie ranges becomes so exceedingly hard and tough that it is a difficult matter to dig up plants by the roots even with a trowel made for the purpose. While the ground is in this state it is simply impossible for the roots of these plants to be pulled up by stock in grazing. After working with plants in a dry condition on the range one naturally comes to doubt whether stock could pull up the roots of plants under any conditions. Observations upon this point after heavy rainstorms, however, will soon dispel all doubt. The local rainstorms, usually accompanied by electrical disturbances, are often almost in the nature of cloud-bursts and are ordinarily very severe. The ground is so thoroughly soaked by these storms that large underground bulbs and thick, tuberous roots are easily pulled out of the ground attached to the stems. It was found that after such storms *Zygadenus* bulbs could easily be pulled up. There seems to be no reasonable explanation of poisoning being more frequent after rainstorms except this loosening of the roots of poisonous plants. It is barely possible that storms accompanied by winds may beat down the weeds and grass together, so that stock will not distinguish between them so readily as under dry conditions.

INFLUENCE OF SNOWSTORMS.

Many serious cases of stock poisoning have occurred after late spring and early autumn snowstorms. In all cases which we have been able to investigate the explanation seems to be that the grass was covered by snow and nothing remained visible for the stock to eat except certain plants which happened to be poisonous. On some of the high ranges in the so-called mountain basins spring snowstorms frequently occur as late as the first of June. Sometimes the snow falls to a depth of 1 foot during these storms, and this depth is sufficient to cover all grass at that season of the year. The tall species of larkspur (*Delphinium glaucum*) usually stands about 2 feet high at that time. This plant is greedily eaten by cattle under these circumstances, largely, perhaps, for the reason that nothing else is to be obtained without digging under the snow. Cattle and horses are the only animals which suffer from poison after late snowstorms, for the reason that sheep are not allowed to graze on the mountain ranges until considerably later in the season, when the danger from snowstorms is past. A number of disastrous cases of sheep poisoning have occurred, however, immediately after early fall snowstorms. In all such cases which we had opportunity to investigate the plant which was responsible for the poisoning was lupine. The conditions were about the same in all cases. The lupine pods had failed to open as completely as they ordinarily do, and a considerable portion of the seeds were, therefore, retained in the pods. The lupine was the only edible material which was left standing above the snow. The influence of snowstorms upon stock poisoning depends, therefore, upon the fact that the late spring and early fall snowstorms frequently cover all forms of vegetation on the range with the exception of some poisonous plants.

DANGER ARISING FROM DRIVING OR TRAILING SHEEP.

Attention has already been called to the fact that many serious cases of poisoning among sheep have occurred while the bands were being driven from one locality to another. The suggestion has already been made by way of explanation that sheep can not make the same choice of forage plants while being hurried over the range as they can under conditions of rest. In following bands of sheep under these different conditions it was observed that a much greater variety of plants and even of noxious plants were eaten by sheep when on the trail than when left to eat at leisure. The more indiscriminate grazing observed under these conditions is perhaps due partly to sheep being worried and partly to their being unable to satisfy their hunger so quickly as under more normal conditions. It would seem highly desirable that, where possible, two herders be detailed with each band of sheep while

they are being driven for long distances, especially if the course of the drive lies in territory that is known to contain poisonous plants. A herder in front of the band might readily detect the presence of poisonous plants upon the range and direct the sheep to one side or the other of this dangerous area. The herder who followed the band might cooperate with the herder in the lead in such a way as to prevent the sheep from becoming too closely packed together.

INFLUENCE OF HUNGER.

The feeding movements of sheep and cattle are much influenced by the condition of the stomach, whether full or empty. It is a well-known fact that ruminants do not feel at ease as long as the stomach is not full. Consequently, where good forage is not present they eat anything that may be obtained, including many noxious plants, and this is especially true of sheep. Eating whatever is in sight, and as rapidly as possible, they are liable to consume large quantities of plants of kinds which when taken in small quantities are not harmful, but which in large amounts may produce serious disturbance. A general rule to be observed in grazing is, therefore, that sheep in a starved or ravenously hungry condition should not be turned upon a range which is known to contain poisonous plants. The disastrous consequences of neglecting this rule are most frequently experienced by men who are shipping sheep long distances by railway. As is well known, the sheep are taken off from the cars for food at rather long intervals and at such times they are always ravenously hungry. It usually happens, also, that they are not acquainted with the plants of localities where they are unloaded for feeding. Serious losses result from allowing them to feed under such circumstances without first inspecting the ground for the presence of poisonous plants.

ACCLIMATIZATION OF STOCK TO THE RANGE.

From the experience of sheep raisers, so far as ascertained, and from observations made in the field during the season of 1900, it is impossible to conclude with certainty that sheep learn by long acquaintance with a given range to avoid all plants of a poisonous nature. It seems certain, however, that on any particular range less poisoning occurs among sheep which are familiar with the range than with strange sheep. This statement is supported by the experience of a majority of sheep raisers as being true for all plants of a poisonous nature except loco. The eating of loco plants seems to be a habit, and on ranges where these plants are abundant it is safe to graze only such sheep as are unacquainted with the plants, or have never acquired the habit of eating them.

INFLUENCE OF THE STATE OF VEGETATION.

The state of the sum total of the local vegetation as affected by seasonal and special weather conditions ordinarily exercises considerable influence on the occurrence or nonoccurrence of poisoning. In the early spring certain poisonous plants may start to grow before the native grasses. In this case, if these poisonous plants are at all conspicuous or offer any considerable amount of succulent material, stock are apt to be tempted to eat them. The acrid, bitter, or otherwise disagreeable taste of such plants seems to have very little influence in preventing stock from eating them. Under the conditions which have just been outlined sheep and cattle eat large quantities of various plants which are extremely unpalatable to the human taste. Later in the season, when grasses and other plants are all in vigorous vegetative growth, it often happens that poisonous plants are eaten along with grasses because of their resemblance to grass, as in the case of *Zygadenus* (death camas), or because of their dark-green and tempting appearance, as in the case of larkspur and water hemlock.

In seasons of unusual drought the native grasses on the range usually mature early in the season. In such cases a number of other plants frequently remain green and tempting to the stock after the grasses have become thoroughly dried. This is especially true of a number of native leguminous plants, among which are several valuable forage plants and some poisonous ones, such as the loco and lupine. In times of drought, accordingly, these plants, including the injurious species, are eaten by stock to a much greater extent than when grass is in a green, normal condition. It was noticed that young lambs when first beginning to eat were especially liable to acquire the habit of eating loco weeds when the native grasses were badly dried up. The same statement may be made of older sheep, with the qualification that they are affected in a less degree. In general, it may be stated as being obviously true that stock will be more apt to eat poisonous plants when such plants offer more tempting forage than the grass. The converse of this statement is also obviously clear that when grasses and other harmless forage plants are present in abundance and in good condition sheep and cattle less often make the mistake of eating poisonous plants.

INFLUENCE OF THE STAGE OF GROWTH OF PLANTS.

The actual stage of growth of any poisonous plant determines very largely whether or not it is eaten at a given time. Some of the poisonous plants—as, for instance, the taller species of larkspur and water hemlock—become so large and coarse during their later stages that they are seldom if ever eaten by sheep in that condition. On the

other hand, the large size or coarseness of the plant does not apparently exercise any influence in preventing cattle from eating it. It is a most noticeable fact in connection with a class of poisonous plants, such as *Zygadenus* (death camas) and the smaller species of larkspur, that the seeds ripen and the whole plant dries up very quickly after flowering. The death camas seems to be especially tempting to sheep just before the flowering stem is formed. Very soon after the flowers have opened, however, the leaves and stem turn yellow and the plant shrivels and becomes much less conspicuous than when in a green condition. Similar statements may be made concerning the smaller species of larkspur.

Thus far the vegetative stage of poisonous plants has been considered only with reference to its influence upon the selection of the plants by stock for forage. It is hardly necessary to observe that poisonous plants can do no harm to stock except as they are eaten. One of the most practical problems, therefore, in connection with the study of poisonous plants is the determination of the circumstances under which stock eat them.

VARIATION AND LOCALIZATION OF THE POISONOUS SUBSTANCES IN PLANTS.

There is another group of facts, partly dependent on stage of growth, partly not, which have an important influence on the dangerous character of poisonous plants. It is found to be true, as will now be shown, that certain parts of a plant may be poisonous while others are comparatively inert, and that the quantity of poison may vary in the same parts of the same species under different conditions and especially at different stages of growth. It is also true that the poisonous principle of a plant is often located in a particular part of a seed or a leaf, so that it is possible that a portion of that organ may be eaten with impunity while other parts would prove fatal if eaten. It will readily be seen that the reputation of a plant as poisonous or nonpoisonous may be affected by these circumstances; since, for example, if a plant is poisonous only at a stage when it is not eaten, its poisonous character would not have opportunity to show itself.

Few of the plants discussed in this report are of sufficient commercial importance to have been studied chemically with anything like the detail necessary in order to draw definite conclusions in regard to the development of their characteristic poisons and their location in the various organs. But it is certain, in the case of the larkspur, at least, as will be shown in the later discussion, that there is marked variation in the quantity of the poisonous substances in the leaf before and after flowering. This may be the case with the leaves of the death camas, but as this plant is not attractive to stock after flowering the question is of less practical importance. It is of interest to note, however, that

merely on account of the fact that stock are seldom killed by death camas after it has blossomed it has been considered by some stockmen as nonpoisonous after that period. As a matter of fact the seed and bulb are alike poisonous, both before and after flowering. The seed is seldom eaten and the bulbs can not easily be pulled out of the ground by stock while grazing after the rainy season in spring is over.

All druggists and physicians are aware that the chemical compound by virtue of which a drug is of therapeutic value is almost invariably more abundant in one part of the plant than in another. The same is true with regard to poisonous principles, as is perhaps best illustrated in the case of Montana plants by the lupines. As is shown in the discussion of these plants, the seed is by far the most poisonous part. There is, also, a particular stage of the plant's growth at which the drug prepared from it must be collected for use. According to the instructions issued by large wholesale dealers in crude native drugs to their collectors these periods are as follows: The roots of perennial plants are gathered at any time between the maturity of the leaves or flowers and the fresh vegetation of the next period of active growth. The roots of biennial plants should be collected at any time after the first year's growth and before they send up their seed stalk the following spring. Barks are gathered as soon as possible after they will peel in the spring, flowers when they first open, and seeds as well as leaves and herbs just before they mature. As a general rule all drugs are most powerful when collected at the appropriate season as outlined above. By observing these rules uniformity of strength, a very essential requirement, is also secured and the drugs are more easily cured and prepared in the most acceptable form for the market. A good example of how a plant may, according to the stage of its growth, be poisonous or nonpoisonous to stock is furnished in the case of the common passion-flower vine in an article published by Mr. Theodore A. Melter in the Bulletin of Pharmacy for May, 1899. It has been ascertained that the drug gathered from this vine is most potent when gathered at the flowering season. Five hundred pounds of the plant which had been ignorantly collected three months later was fed by Mr. Melter to a horse as a substitute for hay, with the result that the animal thrived well and became fat. At another time, however, his horse accidentally gained access to and ate about 30 pounds of the same drug which had been gathered at the flowering season. The horse was found in a stupid state the next day and it remained in this condition, but with loss of flesh, for six weeks, when it died.

In general the part of a plant which causes most cases of stock poisoning is the foliage. The period of its maturity is regarded by some of the cultivators of medical plants as being the time at which its chlorophyll content is most highly developed or when the leaves are most intensely green. This is generally soon after the flowering time in

the case of herbaceous plants, but with some, such as aconite, purple larkspur, poison camas, and many bulbiferous plants closely related to the last, it is earlier, the leaves of some of them having entirely dried up before the plants have flowered. In these cases the leaves would naturally be most active physiologically if eaten before the plants blossomed, and might be practically inert at other times. Such seems to be the case with the purple larkspur. The taste of the leaves, as well as the results of our experiments and the observations of others, indicate that the root as well as the leaves is more poisonous before the flowering time than afterwards. The same is true also of the leaves of the tall larkspur. In both cases the leaves are frequently in the succulent condition after the flowers have expanded.

A very interesting and instructive investigation of the formation and occurrence of poisonous alkaloids in foliage has recently been carried out in the case of the cinchona alkaloids in cinchona leaves by Dr. J. P. Lotsy[1] in Java. The author showed that the quantity of alkaloids varied greatly in the leaf as taken by day or night and on sunshiny or cloudy days, being most abundant in the first instance in each case. He showed also that these alkaloids are formed in the leaves during the day and are almost wholly deposited in the branches or bark at night. If gathered in the early morning, therefore, cinchona leaves would be practically inert, while if gathered in the evening, especially on a sunshiny day, they would be in their most active state.

It has been shown that the location of alkaloids and other toxic substances in plants is not always the same even in similar organs. These are sometimes to be found in the most rapidly growing parts of the plants, as in the white sprouts of potatoes, and again they are to be found in parts which have been fully developed, as in the case of sapotoxin in corn cockle (*Agrostemma githago*). In both of the above cases the remaining portion of the organ is edible. Barth[2] has shown that in aconite seeds the central parts contain most of the aconite, while the seed coats are free from it; in the calabar bean (*Physostigma venenosa*) the very poisonous alkaloid, eserine or physostigmine, is found in the cotyledons; in the seeds of jimson weed (*Datura stramonium*), black henbane (*Hyoscyamus niger*), and belladonna (*Atropa belladonna*) the alkaloids are located chiefly in the layer beneath the epidermis. The epidermis itself and the seed covering is in each case free from alkaloids; in nux vomica seeds, strychnine and brucine are found in the endosperm cells, but brucine alone occurs in the embryo. In jimson-weed seeds the quantity of alkaloids in unsprouted seeds was found to be 15 times as great as in sprouted seeds. In growing colchicum the percentage of alkaloid is very large in the growing tips and comparatively low in the lower part of the bulb. The first year's

[1] Mededeeling uit 'Slands Plantentuin, vol. 36. 1899.
[2] Merck's Market Report, vol. 8, pp. 306–307. 1899.

crop of leaves of foxglove (*Digitalis purpurea*) and henbane is inferior to that of the second on account of the smaller quantity of its active principles and the larger quantity of water and other inert compounds. The variation in strength of the powerfully poisonous drug known as strophanthus is so well known to physicians that its medical use is being abandoned.

Many other instances of the variable location and quantity of poisonous substances in plants might be cited, but these will show the importance of knowing the entire history of a plant in testing its character as poisonous or nonpoisonous.

VARIATIONS IN THE FEEDING HABITS OF STOCK WITH REFERENCE TO POISONOUS PLANTS.

A curious circumstance which one can not fail to observe in the study of poisonous plants is the great variation in the habits of domesticated animals with reference to eating them. This applies both to different individuals of the same species and to the same individual at different times. There seems to be no way of accounting for the appetite or taste of stock. This statement is perhaps especially true of sheep. We have often observed sheep eating greedily on one day plants which they could scarcely be persuaded to eat on the following day on the same range. It is frequently to be observed that one band of sheep eat freely certain plants which are not touched by another band of sheep feeding as nearly as possible under the same conditions. It is also to be observed that there is a striking variation in the taste of different sheep belonging to the same band. It is manifestly not safe to conclude, when a certain number of sheep in a given band are affected by a poisonous plant, that all of the sheep have eaten the plant, and that the ones which are affected are the only ones which are susceptible to the poisonous action of the plant. It would be fully as safe to assume that the affected sheep alone ate the plant in any appreciable quantity. Naturally the variation in the appetite and feeding habits of different sheep is not manifested merely with reference to poisonous plants, but also to forage plants.

It is rather an easy matter in observing the actions of a band of sheep upon the range to note striking differences in the dietetic selections of different sheep. To illustrate, a few observations may be recorded which were made upon a band of sheep on a foothill range at an altitude of 4,600 feet. A few of the sheep were observed eating large quantities of wild sunflower (*Balsamorhiza sagittata*), a few ate freely of false lupine (*Thermopsis rhombifolia*), some confined their attention largely to the wild geranium, while others ate false esparcet (*Astragalus bisulcatus*) almost exclusively. Two sheep were seen eating the leaves of lupine, and about fifty ate a greater or less quantity of *Zygadenus venenosus*, while the majority of sheep in the band fed

exclusively upon the native grasses on the range. It should be stated that these grasses were in excellent condition at the time and the sheep were by no means forced to eat other plants. It may be of interest to note also that no sheep were observed eating the smaller species of larkspur, although this plant grew in great abundance on the range where they were feeding.

Not only are striking differences to be observed in the feeding habits of individual sheep in a given band and in different bands in different parts of the State during one season, but a considerable variation is to be observed in different years on the same range. In many parts of the State the death camas and the small larkspur grow in the same locations, and they are both in their most tempting condition at the same time. Cases of poisoning which occur where both are present are easily traceable entirely to one or the other of these plants. During some years death camas is eaten, while during other years the poisoning is traceable to the larkspur. It is difficult to discover the cause of this variation in the appetite of the sheep. Their arbitrary selection of one plant at one time and another at another time is one of the chief factors in determining the amount of poisoning which will occur on a given range during any particular season. It is the only factor which can not be estimated in any definite manner. It is a comparatively simple matter for the botanist to determine what poisonous plants grow on the particular range and to indicate their relative abundance or scarcity. It is possible to determine by feeding experiments the amount of any particular plant which must be eaten in order to cause death, but no one can with certainty predict whether a given band of sheep will eat any particular poisonous plant when allowed to graze on the range where that plant grows.

EXTENT OF STOCK POISONING.

In order to give an idea of the importance of the general subject of plant poisoning to the stock industry, the cases which came under our observation during the season of 1900 due to the more important poisonous plants are here tabulated. The number of fatal cases is indicated in each case. Probably only about one-fourth of the actual cases came under our notice.

Poisoning cases among cattle, horses, and sheep in Montana observed during the season of 1900.

	Sheep.		Cattle.		Horses.	
	Poisoned.	Died.	Poisoned.	Died.	Poisoned.	Died.
Zygadenus venenosus	3,030	636				
Zygadenus elegans	40	15	6	2		
Lupine	3,000	1,900			1	3
Delphinium bicolor			2	2		
Delphinium glaucum			100	56		
Cicuta occidentalis	105	80	36	30		
Loco weeds	3,550	700	3		150	3
Total	9,725	3,331	147	90	151	6

In the winter of 1898–99, 4,700 sheep were poisoned from eating lupine hay and 1,812 died. In the season of 1900, 150 cattle were poisoned apparently from eating false lupine and 100 died.

EXPERIMENTS ON RABBITS.

Most excellent facilities for observing cases of stock poisoning as they occurred in the field were afforded us in 1900 from May until July, but often it was impossible for either of us to be on hand when the animals were first poisoned. In practically all accidental cases occurring on the ranges it is impossible to make anything like a satisfactory inspection of the symptoms of poisoning or to estimate the quantity of the plant eaten, and it is often difficult even to determine the plant, still more the particular part of the plant which caused the mischief. Besides, the accidental cases ordinarily observable cover about five or six of the several dozen plants which have been cast under suspicion by the stockmen of Montana and concerning which it was necessary that they should have some definite information. For these reasons it was necessary to make numerous experiments with various plants on inexpensive animals. Rabbits were selected for this purpose because, being herbivorous in their nature, they more closely resemble stock, so far as their eating habits are concerned, than any other commonly domesticated pets. The necessity of choosing by this standard is apparent when one considers the wide difference in the susceptibility to certain poisons shown in various animals having different feeding habits and corresponding differences in the nature and extent of the digestive areas in the stomach and intestinal canal. So, too, there is a difference in the susceptibility which is somewhat correlative to the general, and especially to the mental, development of the animal.[1] The brain and nerve poisons, such as morphine, atropine, conine, and aconitine, are much less poisonous to animals than to men. Dogs and horses can, in proportion to their weight, endure ten times as much morphine as men, while doves can stand five hundred times and frogs even a thousand times as much. In herbivorous animals, especially in those which chew their cud, such as sheep and cattle, the digestive tract is much longer than in the case of omnivorous or carnivorous animals, consequently the food remains in the body for a much longer period. In case of herbivorous animals this period is usually several days, while in carnivorous animals it is about twenty-four hours only. In the former case, therefore, the poison would have much more time to become absorbed into the blood than in the latter case. This, according to Fröhner, probably explains why it is that the metallic poisons are much more fatal to herbivorous than to carnivorous animals. The fatal dose of calomel is given for a cow as practically the same as that

[1] See Fröhner, Lehrbuch der Toxicologie für Thierarzte, pp. 12, 13. 1890.

for a hog, notwithstanding the difference in size. It takes over a pound of the sugar of lead (lead acetate) to kill a horse, while a tenth of that quantity will kill a cow of equal weight. Chemical reaction between the digestive juice of various animals and the poisons contained within the plants, as well as the chemical reactions between the poisons and the chemical constituents of the various food stuffs, undoubtedly have considerable influence in some cases on the effect of poisons before they are taken into the blood. If, for example, a plant containing a poisonous alkaloid were eaten together with another containing tannin, some or all of the alkaloid would be rendered inert by the formation of the insoluble tannate of the alkaloid. So, too, physiological processes in one animal may tend to retard the absorption of the poison from the stomach, while in others they may exert no such reaction. In the latter case, of course, the poison will exert its influence on the system before there is any chance for it to be eliminated.

The fundamental rule relative to the effect of the poisoning of any animal is that a certain amount of the toxic substance must be in circulation in the blood and that the amount circulating depends not only on the amount administered but on the rapidity with which excretion takes place. It may, therefore, happen that very poisonous substances may so quickly be eliminated by the animal that there will never at any one time be a sufficient amount of it in the blood to produce a fatal effect or even any effect at all.[1]

From the foregoing it is evidently quite probable that the susceptibility to some poisons will differ in the case of rabbits as compared with that of stock. As a rule, however, the results obtained with rabbits are considered by pharmacologists as trustworthy indications of the effects which would be obtained by similar experiments upon stock. The animals must, of course, be in a healthy condition when used.

The general method of procedure, which after a few preliminary experiments was adopted in our work, was as follows:

A definite quantity of the fresh plant or an extract thereof was offered to a rabbit of known weight and the results noted in chronological order. The weight of the fresh material eaten was determined by subtracting the weight of the residue left after a certain time and making a proper allowance for the loss of its weight due to the evaporation of water from its tissues. To ascertain this loss a weighed portion of the material identical with that which was fed was subjected as far as possible to the same evaporation influences and again weighed at the end of the experiment.

In several cases it was found that the rabbits would either eat but a very small quantity of the plant or eat it too slowly for a satisfactory test. In this case extracts were made and fed in known quantity by

[1] Hermann's Experimental Pharmacology, p. 65. 1883.

means of an ordinary syringe and a piece of rubber tubing. The tube was well oiled and shoved gently into the animal's stomach, connection made with a syringe, and its contents injected into the stomach. In every case the extracts represented a definite quantity of the fresh plant. If the first injection produced no characteristic symptoms within a half hour, a larger dose was given, and this operation repeated until the true character of the plant was established. When the fatal dose was determined other animals were given an equal quantity and the effect of antidotes, especially of the permanganate of potash, was determined. In view of the large number of plants to be tested, only two extracts, one aqueous and one alcoholic, were used in most cases. A more satisfactory examination would have been made if we had used about a half dozen of the more common solvents, but lack of time would not permit this, and it was thought, moreover, that working as we did, with fresh, green material, the toxic substances would be more soluble in water than if the dried plants had been used. The aqueous extract was tried first, then the extract from the well-pressed residue used for obtaining the aqueous extract, was given. The poison in the latter case being in a solution of 50 per cent alcohol, it was necessary to dose other rabbits with equal quantities of alcohol in order to note the difference in effect which was due to the poison. The alcohol given with the poison may in some cases have acted as a partial antidote in modifying the symptoms, and in some cases it may have increased the intensity of the action, but as the amount given was in almost every case very small it could have had but little effect on the ultimate action of the poison, the real point at issue.

Care was observed in most of the experiments made to use fresh unwilted plants of a definite stage of growth and to cut up a weighed quantity finely in a sausage grinder, saving all of the juice and extracting this material for about twelve hours with a definite weight of water or 50 per cent alcohol, in no case applying a higher temperature for the extraction than that normal to the human body. The aqueous extracts were used within a few days after their preparation in order to preclude changes which might be brought about by molds, which in some cases attacked the extracts within three or four days. No difficulty was experienced in keeping the alcoholic extracts in an uncontaminated condition.

A few of the extracts were, on account of the short time at our disposal, tested hypodermically on the rabbits. In these cases it was our object simply to discover whether the plants were poisonous or not, and due allowance was made for the difference in the method of introducing the poison into the system. As is well known, all poisonous substances are more energetic when injected under the skin than when taken into the stomach. Some, such as dilute mineral acids and the venom of certain poisonous snakes, are practically inert when taken

into the stomach, but are fatal if injected into the blood. The difference in the fatal dose when injected hypodermically and when fed varies somewhat according to the poison and also to the kind of animal used. With strychnine, for example, the ratio between the fatal dose given hypodermically and that given by way of the stomach is one to ten in sheep, one to five in horses, one to three in pigs, and one to two in dogs. This ratio in the case of sapotoxin, a poisonous substance found in many plants, is nearly one to one hundred in the case of animals having a healthy alimentary tract. When the latter is ulcerated, however, the sapotoxin is far more poisonous. This explains why it is that some animals in a herd or pen are sometimes killed by eating a certain plant, while others eat it to a certain extent with impunity.

METHODS OF PREVENTION AND REMEDIES.

DISPLACING POISONOUS PLANTS BY FORAGE PLANTS.

The use of aggressive forage plants for the purpose of displacing poisonous plants upon the range has been attempted on a small scale in various parts of the State. The preliminary experiments with such forage plants are being conducted by the Montana Experiment Station and by various stockmen with a view to determining whether such plants are able to maintain themselves under the semiarid conditions of the Western cattle ranges. The only forage plants which have been used for this purpose are smooth brome grass (*Bromus inermis*) and western wheat grass or "bluejoint" (*Agropyron occidentale* Scribner). Both of these grasses make a vigorous growth upon the ranges of the plains and mountains. The smooth brome grass has been widely distributed in the Western States in the hope that it might prove a valuable pasture and meadow grass under semiarid conditions. Naturally, however, it attains a greater size and covers the ground more completely when supplied with an abundance of moisture than when growing in dry situations.

Judging from the present conditions in Montana it will require several years for the smooth brome grass to form a sufficiently thick sod to displace larkspur, death camas, or loco weeds, which are indigenous to the locality. Under dry conditions the smooth brome grass seems to cover the ground rather slowly. In many areas of this grass, where it had been growing for two or three years, the stools were well separated by considerable intervals of bare ground. The bluejoint spreads more rapidly from the root, and is usually more aggressive than the brome grass. Apparently, however, bluejoint does not do well on the dry ranges. The short-awned brome grass (*Bromus marginatus* Nees), a native species, is spreading rapidly in a number of localities in various parts of the State. In some places this grass had already displaced all other native plants and occupied the ground completely.

On a cattle ranch near Augusta it has invaded a timothy meadow and entirely killed out the timothy as far as it has spread. This brome grass produces a heavy crop of hay, and a few stockmen, having noticed its good points, are preparing to save seed for sowing upon other parts of their ranges. Although work and observations along this line extend over only three or four years, the outlook is promising, and it is perhaps not unreasonable to hope that by assisting the distribution of the brome grasses, bluejoint, and other aggressive forage plants the quantity of poisonous plants upon the range may be appreciably diminished. Both the smooth brome grass and the short-awned begin to grow in the spring earlier than the other range grasses or poisonous plants, and both these grasses are greedily eaten by all range stock. This being the case, it is evident that stock will be less apt to eat poisonous plants in the early spring when these desirable grasses have become established in great abundance.

HERDING STOCK AWAY FROM DANGEROUS AREAS.

Attention has already been called to the possibilities of avoiding poisoning plants by judicious herding. In the present state of the study of poisonous plants perhaps the most important practical recommendation is that all herders should be made thoroughly familiar with the appearance of the different poisonous plants in all their stages. This familiarity should be such as to enable the herder to recognize them at a glance, and to put him in a position, therefore, so to direct his sheep that they will avoid the areas where poisonous plants grow. This knowledge is especially desirable for herders when caring for sheep on the trail or at feeding stations. In discussing lupine poisoning a case will be mentioned in which 400 sheep died from eating lupine immediately after being unloaded from the cars. It would not have been difficult to prevent these sheep from getting the lupine at the time if the herder had known the dangerous nature of the plant. Another instance of this sort happened at Baltic, where a band of sheep was unloaded for quarantine on account of suspected scab. During the first day after being unloaded the sheep ate death camas, and 100 of them died. The herder recognized the plant, and after that day avoided areas where it grew, with the result that he lost no more sheep.

In a dry climate such as that of Montana it is well known that on portions of range where animals are not allowed to feed the native grasses attain a considerable height, come to maturity, and remain standing in the condition of hay without losing any nutritive principles. It is, therefore, quite possible for a sheep raiser to abandon any range which is badly infested with poisonous plants until late in the summer or until fall, when these poisonous plants are too coarse and dry to be tempting. No loss of forage will be suffered by adopting

this course, since the range which is abandoned in summer will be good for winter grazing. By giving serious attention to the problem of poisonous plants and becoming familiar with the time of the first appearance in the spring, the time of blooming, and the period when they begin to shrivel up, and by bearing in mind the period of growth during which they are poisonous, the stockman will be able so to direct the movements of his animals as to avoid a large proportion of his annual loss.

ERADICATION OF POISONOUS PLANTS BY DIGGING.

The possibility of eradicating a given plant from a range will depend almost entirely upon the extent of its distribution and upon the definiteness and size of the areas upon which it grows. In the case of the tall larkspur, which ordinarily grows in small, well-defined areas, it would be a comparatively simple undertaking to dig up all the specimens within the reach of cattle upon the range. On the other hand, it is manifest that plants which are widely distributed and which occur under a variety of conditions of soil and moisture could not be exterminated by this means. As examples of such plants we may mention the loco weeds and death camas.

POPULAR METHODS OF TREATING POISONED ANIMALS.

Serious mistakes have been committed by many herders in the care of poisoned sheep. It seems to be frequently assumed that animals which are suffering from the effects of poisonous plants must be kept moving under any and all circumstances. In order to do this the herder is forced to make free use of the dog and otherwise worry and excite the sheep. A general principle of great importance in the treatment of poisoned animals is to let them alone as far as possible. Cases of narcotic poisoning may be an exception, but with the ordinary kinds of poisoning the inevitable result of all unnecessary excitement is to exaggerate the symptoms and to precipitate a fatal outcome. It has been noted that among the symptoms of poisoning an increasing rate of respiration and heart beat is especially prominent. Evidently when such symptoms are present it is not advisable to excite the poisoned animals in any manner, since such excitement would produce a still higher rate of respiration and pulse. In a serious case of larkspur poisoning of sheep, which occurred in Montana in 1897, it was found that in attempting to hurry the poisoned sheep the severity of the symptoms increased, producing fatal results in many cases in which there would otherwise probably have been recovery. Even where frenzy is the prominent symptom it is probably advisable to allow the animals to move about without restraint except during the administering of remedies. Any interference with the movements of the poisoned animals is especially liable to increase the excitement, already too great

in cases where cerebral symptoms are prominent. Where no remedies are at hand for immediate treatment, it is always advisable to leave the animals to themselves, allowing them to lie down and remain quiet if they will. In the case of sheep it is, of course, impossible to leave them unprotected upon the range over night, for the reason that coyotes and wolves would destroy them. If a large number of sheep are affected at the same time, it will be desirable for the herder to stay out over night with them. If, on the other hand, only a small number of sheep are poisoned, it will be possible to haul them in a wagon to the corral.

In nearly all cases of stock poisoning the sheep herders and cowboys at present resort to bleeding. A considerable difference of opinion prevails among them as to the best place at which to operate. Some prefer the root of the tail, others the ear, and still others the inside of the lips. Bleeding at one or the other of these places is said to be quite uniformly efficacious, and is tried with great confidence by the sheep herders and cowboys. As is well known the practice of bleeding was constantly employed in the early history of human medicine, and was considered beneficial for all sorts of ailments. The same might be said of the early history of veterinary medicine. During recent years, however, the practice has been abandoned except in a few special instances where it seems to be directly indicated as the appropriate procedure. With regard to bleeding poisoned animals, it is obvious that the practice will have a good or bad effect according to the symptoms and condition of the animal in question. If the poisons which are concerned have a depressing effect upon the heart, it is evidently wrong to further increase their action by withdrawing the blood and thus lowering the blood pressure. A number of poisonous plants have this effect upon stock, and where they have been eaten stimulants are plainly indicated as the proper remedy. If, on the other hand, the symptoms of poisoning are those of an increased blood pressure accompanied by cerebral excitement and a hard, wiry pulse, bleeding might furnish temporary relief. Notwithstanding the confident manner in which herders and cowboys speak of the beneficial effects of bleeding in all cases of poisoning it remains very doubtful whether the practice is to be recommended in any case. It may be safely asserted that the practice of bleeding indiscriminately does more harm than good.

It is a quite general practice, also, to give melted lard or fat pork in any case of stock poisoning by plants and especially in case of bloat. One of the well-known effects of these substances is a more or less decided cathartic action, and this action is desirable in so far as it helps the animal to eliminate the unabsorbed parts of the poisonous plant. A further beneficial action of the lard may consist in the hindrance to the absorption of the poisonous alkaloids by the formation of a temporary oily coating upon the stomach wall. In cases where the

poisoning is not severe and the symptoms not specially violent it is probable that liberal quantities of lard administered soon after the symptoms appear may assist materially in bringing about recovery.

Many stockmen administer drenches of soda indiscriminately in almost all cases of poisoning. But soda being an alkaline substance has primarily the effect of neutralizing any acid condition of the stomach. If a fermentation with an alkaline reaction were already in process in the stomach it is difficult to see how soda could have any beneficial effect. In cases of bloat from eating large quantities of clover or alfalfa soda seems frequently to have beneficial effects.

Vinegar is another remedy which is often applied in case of stock poisoning. This substance is given in cases where for any reason it is suspected that the stomach contents are strongly alkaline. Under such circumstances it might be expected to counteract the alkaline condition. One stockman informed us that he usually gave both soda and vinegar simultaneously, hoping thereby to counteract whatever condition was present in the stomach, whether alkaline or acid. It is quite unlikely that any beneficial results would come from such a procedure, since the soda and vinegar would neutralize each other.

PERMANGANATE OF POTASH AS A CHEMICAL ANTIDOTE.

It will be observed from the foregoing account of the popular remedies employed by stockmen that they have no general, simple, and reliable rule for selecting antidotes or for the application of remedial measures. This deficiency may be supplied to a large extent by adopting the regular use of a solution of the permanganate of potash, which, as will be shown later, is a very effective antidote in some cases of poisoning by plants and chemical compounds of plant as well as of animal and mineral origin. Besides being efficacious, its administration is so simple and its mode of action so easily understood that we do not hesitate to recommend it as an antidote to be seriously considered in certain combinations in almost all cases of the poisoning of stock by plants.

Under the names of Condy's fluid and mineral chameleon, the permanganate of potash, on account of its powerful oxidizing properties, was first introduced in 1856 by Mr. Condy, of England, as a disinfectant or wash for ulcers and festering skin diseases, and for sanitary purposes, such as the destruction of filth germs and their poisonous products. It was prescribed internally as a remedy for diabetes without success as early as 1853. But its internal use as an oxidizing agent was not strongly advocated until 1864 and 1866, when Madamet[1] and Muter[2] published comprehensive articles alleging the value of an

[1] Sur l'emploi therapeutique du permanganate de potasse. Thesis, pp. 30, Strasburg. 1864.

[2] The alkaline permanganates and their medicinal uses, pp. 48, 16mo., London. 1866.

aqueous solution of the salt in healing various stomach and intestinal as well as general diseases, and in cleansing the system from foul matter. No ill consequences attended such use even when comparatively large doses of the solution were taken.

The use of the permanganate salt solution as a chemical antidote to oxidize organic poisons which might accidentally get into the stomach was suggested by Muter, but no effort to utilize his suggestion was made until 1881, when Prof. J. B. Lacerda,[1] of Rio Janeiro, Brazil, announced the result of his investigations relative to the hypodermic use of the salt as an antidote for snake bites. Lacerda's paper was widely copied in France and throughout Europe, and as a result permanganate of potash, especially in alkaline solution, is still regarded as a most efficient antidote against the poison of various snakes if promptly injected into the wound. Some persons whose duty it is occasionally to handle poisonous snakes always have the means to apply this remedy at hand when there is danger of being bitten.

Chemists have long been familiar with the rapid decomposition which is caused in many organic compounds by permanganate of potash. In 1886 Beckurts and List[2] showed that several very poisonous alkaloids, such as brucine, veratrine, conine, and nicotine, were instantly decomposed by it, while still others were oxidized in varying periods of time. The authors did not, however, suggest that the salt had any value as an antidote.

In 1891 Antal[3] showed that the dilute solution of permanganate of potash was an efficient antidote against the effects of phosphorus, which was oxidized by it in the stomach to phosphoric acid, a comparatively nonpoisonous substance. Again in 1892 the same investigator showed that this salt was a valuable antidote in cases of poisoning due to strychnine, colchicine, muscarine (the poison of the fly amanita, *Amanita muscaria*), the oil of sabine, and oxalic acid. He also suggested that it would probably prove of great value in human cases of poisoning from many compounds of either animal or plant origin. In every case a dilute solution of the antidote was given by way of the mouth. No experiments were made upon stock.

Since the publication of Antal's work other investigators have employed dilute solutions of the permanganate of potash, generally without combination with any other substances, in case of poisoning from coronillin, prussic acid, atropine, aconitine, nicotine, curarine, strychnine, and morphine. Its use for all of these compounds was attended with success in experiments made upon animals, but as yet there has been but little chance, except in case of morphine and of phosphorus, to substantiate its value by clinical treatment sufficiently

[1] Compt. rend. Acad. sci. Par., vol. 93, pp. 466–469. 1881.

[2] Druggists' Circular, vol. 30, p. 176. 1886. (From Pharm. Zeit.)

[3] Orvosi Hetilap., vol. 35, pp. 591, 592, and 606, 607. 1891.

to warrant its use to the exclusion of other antidotes. In case of some of these substances the comparative slowness of the oxidation, as observed in chemical experiments with the pure salt, does not warrant its use. It has been asserted that hypodermic injections of the permanganate are of value in antidoting the effects of poisons which have already passed into the general circulation. But from a purely theoretic standpoint this does not seem probable and, moreover, the clinical results do not seem to warrant the statement.

The value of permanganate of potash depends almost exclusively on its strong oxidizing power. When taken into the stomach it is reduced or destroyed more or less quickly according to the nature and quantity both of the food and of the stomach contents in general. To be at all efficacious as an antidote the solution must of course react upon all or a great part of the poison before it acts upon the other contents of the stomach. It is evident, therefore, that the more rapidly it reacts upon any poisonous substance in the presence of the other organic matter usually contained in the stomach, the more effective it must be as an antidote for that substance. For instance, Dr. William Moor[1] has shown by experiment that if to a solution of one grain of morphine sulphate, dissolved in an ounce of water, and 250 grains of the white of egg, one grain of the permanganate of potash, dissolved in an ounce of water, be added, the morphine will be immediately destroyed without the albumen being affected. To convince the medical fraternity of the practical value of the antidote he semipublicly swallowed 3 grains of morphine sulphate followed in about 30 seconds by 4 grains of potassium permanganate. No ill effects were observed, although the dose taken would ordinarily have proved fatal. In order to obtain any results with the antidote it is absolutely necessary that the poison should be in the stomach or in the intestinal canal when the antidote is given. It can not when taken either into the blood or into the stomach react on the poison which has already been absorbed into the general circulation unless, as modern investigation has shown is sometimes the case, the poison is eliminated from the blood by the cells in the glandular lining of the stomach. In an investigation made by Prof. Edward Hitzig and quoted by Dr. Moor, the former took from the stomach of a dog half of the morphine which had been given it subcutaneously. As these poisons are reabsorbed from the stomach and intestines and pass again into the stomach, it is evidently advisable in such cases to repeat the administration of the antidote one or more times at short intervals (of about a half hour), until all of the symptoms have disappeared.

It was stated above that the permanganate of potash is destroyed in the stomach more or less rapidly according to the nature and quantity of the material contained along with it. It is highly important to

[1] New York Medical Reporter, vol. 45, pp. 200, 201. 1894.

recognize the fact that this rapidity may be favored by the presence of certain compounds. It is known that some complex organic substances are more readily decomposed by the permanganate salt in alkaline solution than with acids, but it is believed that the reverse is the case with a great majority of poisonous compounds. In general, the oxidation is not only more rapid in the case where an acid is present but it is also more complete, a larger amount of oxygen being made available for the purpose. In some instances the amount of oxygen liberated with the acid is nearly twice as great as with the alkali.[1]

Almost all of the purely medical investigators have failed to appreciate the full value of this joint use of other substances with the permanganate solution in favoring a more rapid and complete reaction. No one has laid particular stress upon the point, although Antal in his first paper suggested that the use of vinegar or lemon juice would result in the liberation of more oxygen from the permanganate. In the case of the phosphorus poison, however, he considered the acid unessential, and he did not make any use of the idea in his other work. Schlagdenhauffen and Reeb[2] also noted, in 1893, that in test-tube experiments the decomposition of coronillin, the poisonous glucoside of a European leguminous plant known as *Coronilla scorpioides*, was hastened not only by the presence of sulphuric acid but by that of carbonate of soda and various salts, such as the sulphates of potassium and sodium, phosphate of soda, and common salt (sodium chloride), but he made no use of the suggestion, other than to show how the reaction might be favored when the permanganate was injected into the blood, this fluid being alkaline and containing all of the salts above-mentioned. Dr. Moor has suggested an addition of sulphuric acid or white (not red) vinegar to form a salt in cases where morphine, an insoluble alkaloid, is in the stomach, the idea in this case being to get the alkaloid into a soluble condition, in which case it will, as is the case with many alkaloids, more readily unite with other compounds.

In all of our own experiments aluminum sulphate, a common salt,

[1] This is shown by the following equations:

$$2\ KMnO_4 + 2\ KHO = 2\ K_2MnO_4 + H_2O + O$$
$$2\ KMnO_4 + 3\ H_2SO_4 = K_2SO_4 + 2\ MnSO_4 + 3\ H_2O + 5\ O$$

The soluble potassium manganate which is immediately formed in the first reaction is gradually decomposed into the presence of water to the peroxide of manganese, which is precipitated into caustic potash and into oxygen. Thus:

$$2\ K_2MnO_4 + 2\ H_2O = 2\ MnO_2 + 4\ KHO + 2\ O$$

As seen in the second equation, the permanganate is at once decomposed into manganese sulphate, a soluble salt representing the lowest oxide of manganese, and at the same time a larger quantity of oxygen is liberated than in the first case, the proportion for the complete reaction being three molecules for the alkali to five for the acid.

[2] Journ. der Pharmacie von Elsass-Lothringen, vol. 20, pp. 321–325. 1893.

obtainable at any drug store, was used with the permanganate of potash on the ground that it is acid in its reaction and can be far more readily and safely used by stockmen than acids can. No experiments were made with the permanganate in alkaline or in neutral solutions, because the results obtained with the acid salt were wholly satisfactory and we desired to utilize the full oxidizing effect of the permanganate. An animal's stomach is usually acid in reaction, but it was feared that on account of the general alkaline condition of the water which is drunk freely by stock in Montana, the stomachs of some animals might not be sufficiently acid to insure the complete oxidation of the permanganate solution.

W. D. Zoethout[1] has shown that the fatal effect of some toxic substances, such as potassium cyanide and atropine, is hastened in the case of a certain low form of unicellular protozoan life known as *Paramoecium aurelia*, if an acid is present at the same time and is retarded by the presence of the alkali, sodium hydrate. The effect is purely physiological. This retarding value has not as yet been confirmed in an experimental way upon animals; still it is quite possible that the extended use by the stockmen of Montana of sodium carbonate, the physiological equivalent of sodium hydrate, as an antidote to the poison of plants may really be a practical demonstration of the matter. On this account, also, it may be advisable in some instances to use with the permanganate an alkali instead of an acid. In case the oxidation is not completed in the stomach the alkali might tend to retard, if it did not completely offset, the effects of the toxic compound already absorbed into the system. It is certain, however, that in case of death camas and larkspur, the two most important groups of poisonous plants in Montana, it is advisable to use the permanganate in acid solution, or, more conveniently, with aluminum sulphate. Our experiments with this salt mixture are described under death camas, larkspur, and false hellebore. Although not so extended as we could wish, they indicate that the antidote will prove to be generally successful in cases of poisoning caused by these plants, and we do not hesitate to recommend it as an emergency antidote in all cases of plant poisoning, especially in those which are observed shortly after the plants have been eaten. Other antidotes must be relied upon if a fatal dose has already been absorbed from the stomach.

Sheepmen have a great advantage over cattlemen in the use of this antidote, because sheep, being constantly herded, are soon detected when poisoned. It takes considerable time for the poison to be extracted from the various parts of the plant eaten and to be absorbed from the stomach, so that if the antidote is administered immediately, as would naturally be the case, there is an excellent chance to destroy most of

[1] Science, n. ser., vol. 8, pp. 776–778. 1898.

the poison before it is absorbed. It would be advisable, on account of the coarse plant particles which are found in an animal's stomach and the consequent slow process of extraction, that the permanganate and aluminum mixture should be administered again after an interval of perhaps a half hour, but this did not seem to be necessary in our experiments. The necessity should, in each case, be determined by the effect of the previous dose. If the animal is at first relieved and then succumbs again to the symptoms the dose should be repeated.

DIRECTIONS FOR USING PERMANGANATE.

In case of poisoning by plants, especially by death camas and the larkspur, a solution containing equal weights of permanganate of potash and sulphate of aluminum should be administered at once. For adult sheep, take, according to the weight of the animal, from 5 to 10 grains of each of these compounds dissolved in water and give as a drench. The same dose should be given to hogs. Fifteen to 20 grains are required for horses and from 30 to 50 for cattle. These doses are for adults; for very young animals (from 2 to 4 months old) the dose should be made proportionately smaller. In making these solutions the water used should be sufficient for drenching purposes and may vary from a pint to a quart, or even more. The water should be pure well or spring water which is not too strongly alkaline; the chemicals should be very finely powdered to insure rapid and complete solution, and care should be taken that they are entirely dissolved before the solution is used. For emergency in case a large number of animals should be poisoned at the same time, five hundred or a thousand doses of the dry finely powdered salts should be kept at hand for immediate use. There is little danger even within the wide limits given in the last paragraphs of administering an excessive dose of this antidote. In one case as much as $3\frac{2}{10}$ grains of each salt was given within one and one-half hours to a 2-pound rabbit without causing any ill effect. It is very necessary, however, to observe one precaution. *All of the salt mixture given to the animal must be in solution.* The solid particles, if swallowed, will stick to the walls of the throat or stomach and cause intense irritation and may kill the animal. A few fatal cases of human poisoning are on record which were caused in this way. Since the solution of the permanganate of potash, owing to the intensity of its purplish color even in dilute solutions, is almost opaque, the only practical way to note whether all of the salt is in solution or not is to carefully pour off the liquid occasionally after it has been allowed to stand a minute or two and to see if there is still a crystalline residue. As neither of the salts are very rapidly soluble in water, especially when not finely powdered, it may require several minutes before they are completely dissolved.

METHOD OF DRENCHING.

The sheep is a docile and easily managed animal, so that no method of applying remedies presents any difficulties. The only question in this connection to be considered by the sheep owner is that of the convenience and rapidity of application. In cases where hundreds of sheep are poisoned simultaneously no direct remedy is practicable which requires special skill or any great length of time for its application. Probably the method which will prove most convenient for the stockman is that of drenching. For this purpose a cow horn, long-necked bottle, or regular drenching bottle may be used.

In drenching, the sheep should be set upright and care should be exercised that the solution is not spilled or wasted. With but little experience the drench may be given rapidly with no danger to the sheep. Where any considerable number of sheep are poisoned at one time it will be found convenient to dissolve a large quantity of potassium permanganate in such proportions that an amount of the solution convenient for drenching, say a pint, will contain the required amount of potassium permanganate. This substance is a powerful agent and forms a somewhat explosive mixture when combined with organic substances, and therefore must not be mixed with sirup or similar substances. Otherwise, no special precaution is to be observed in its use. It would, of course, be a strong irritant if taken as a salt or in a concentrated solution, but no injurious effects were noted when solutions of the strength recommended were given to lambs two weeks old.

The difficulties of drenching horses and cattle are not great in case of dairy cows and family horses. In treating range stock, however, it will be necessary, of course, to rope the animal before administering the drench.

On account of the physiological action of a few poisonous plants in causing paralysis of the throat, or because of the difficulty in managing an animal, it is sometimes impossible in the case of sheep, cattle, and other ruminating animals to force the antidote down the throat. In this case the solution should be injected directly into the stomach through the walls of the body. As is well known, the stomach in ruminating animals is joined without any intervening spaces, as in the case of horses, to a certain part of the body wall. This circumstance renders it safe by use of the trochar and canula, sold by dealers in veterinary instruments for the purpose (or even a common knife), to make an opening into the stomach and to inject the antidote. It is a common practice thus to perforate the stomach of a cow or sheep to relieve gas pressure in case of bloat, and the same method is occasionally employed in administering medicines. A full account of the practice, with directions for locating the particular area for the incision, is given in the directions for the treatment of bloat.

TYMPANITES OR BLOAT.

It is well known to stockmen that a number of the legumes may produce serious or even fatal cases of bloating in sheep and cattle. The plants which most often cause this trouble are alfalfa, white clover, and red clover. As a rule these plants produce bloat only when eaten in a green condition. A few cases of tympanites, however, have been reported as due to eating one or the other of these plants in the form of hay. Stockmen frequently allow cattle and sheep to graze upon clover and alfalfa meadows in the late fall after the stock has been brought in from the range. At such times the clover and alfalfa usually have a height of about 4 to 6 inches and are still growing more or less vigorously according to the prevailing temperature. Cattle and sheep frequently suffer from various digestive disturbances which are due to the sudden change of diet from the dry grass upon the ranges to the green succulent growth of the young clover and alfalfa.

In regard to the tendency to produce bloating, there seems to be little difference between the cultivated clover and alfalfa. There is, however, a strong belief among a large number of stockmen that these plants do not cause bloat except under peculiar conditions. It is frequently asserted that green alfalfa and clovers may be eaten with impunity by cattle or sheep at all times except when moistened by dew or rain. Other stockmen believe that these plants are more likely to produce bloating when eaten immediately after a slight frost. No experiments have been conducted which would either prove or disprove these beliefs.

It appears to be well established that cattle and sheep may become accustomed to eating these plants in a green state so that no bad effects are produced by feeding upon them. It is, perhaps, to be considered unwise to allow stock which are not accustomed to these plants in a green state to feed upon them exclusively. A better plan would be to permit such animals to graze upon them for a short time each day until the digestive organs have become accustomed to the change of diet.

A considerable number of sheep and cattle die every year from bloating, and this trouble becomes quite serious at times. In the case of bloat the production of gas in the first stomach of sheep and cattle goes on so rapidly that the animal may die within from fifteen minutes to two hours unless assistance is rendered by the attendants. With sheep the timely detection of bloating is rendered easy by the fact that these animals are kept under the constant attention of a herder. With cattle the matter stands very differently. Little attention is paid to their movements, and consequently it frequently happens that cases of bloating among them are not noticed until after the death of the animal.

The remedies in common use by herders and cowboys for preventing fatal results from bloating are doses of lard or fat pork, and paunching or rumenotomy. The usual method of making an incision in the stomach is by means of a long knife with a blade an inch or more in width. The knife is plunged directly through the body wall and into the stomach with a single stroke. The gases are thus allowed to escape through this opening and the pressure within the digestive organs is relieved. Some stockmen prefer to use the trochar and canula, which are especially designed for such cases and are for sale by dealers in veterinary instruments. The chief advantage is that the opening made by this instrument is much smaller than that produced by the knife, heals more readily, and is less likely to result in any complications.

With regard to the value of these remedies for bloating it may be stated that they are exceedingly effective and quite safe in the hands of the average herder and cowboy. A few cases were observed in sheep where the herder had cut a slit of the length of 5 or 6 inches through the walls of the stomach, thus rendering it almost impossible for the wound to heal without the use of sutures. It is entirely unnecessary, however, to make incisions of greater length than 2 inches either in sheep or cattle to allow the gas to escape readily. In cases where the formation of gas does not take place rapidly and where the animals are noticed as soon as they begin to bloat the liberal application of cathartics is often quite sufficient to check the process of fermentation. Large doses of soda may also be given in connection with cathartics. Where, on the other hand, the production of gas has gone so far that the animal is unable to walk, immediate relief is necessary in order to prevent fatal consequences. The gas pressure upon the inside of the first stomach may become so great as to interfere with respiration and the action of the heart, or even to rupture the diaphragm or the stomach walls. The only way in which this pressure may be relieved is to make an incision directly into the stomach through that part of its wall which is adherent to the body wall, as already explained.

A number of stockmen have inquired concerning the exact point at which the incision should be made. The proper place is located upon the left side of the body at a point equidistant from the last rib, the angle of the hip bone, and the vertebral column. After a little experience it will be easily found.

NONPOISONOUS PLANTS WHICH ARE MECHANICALLY DANGEROUS.

There occur in Montana, as indeed throughout the entire West, occasional losses of stock which are due to plants acting in a purely mechanical way, no poisonous substance being present. We refer to

DEATH CAMAS (ZYGADENUS VENENOSUS).

the penetrating action of the sharp barbed awns of the porcupine grass (*Stipa spartea*) and squirreltail (*Hordeum jubatum*). Both of these grasses make good fodder if cut when they are still young, but when nearly mature the awns easily separate and frequently get into the mouth and throat or the eyes and ears of stock, where they penetrate into the tissues and give rise ultimately to ulcers which cause such intense suffering to the animal that it must sometimes be killed. The squirreltail grass is well known throughout the State; the porcupine grass is not nearly so common.

PLANTS POISONOUS TO STOCK IN MONTANA, OR SO REPUTED.

MOST IMPORTANT POISONOUS SPECIES.

DEATH CAMAS.[1]

(*Zygadenus venenosus* S. Wats.)

Other names: Poison camas, lobelia, squirrel food, wild onion, poison sego, poison sego lily, mystery grass.

DESCRIPTION, HABITAT, AND DISTRIBUTION.

A smooth, simple-stemmed perennial with a coated, onion-like bulb, narrow, linear leaves, and a short terminal cluster of yellowish-green flowers. The plant grows everywhere in Montana in moderately moist places on open ranges. Outside of Montana it is found from British Columbia to South Dakota, Nebraska, Utah, and California.

Of all the various plants which are known or suspected to poison stock in early spring in Montana the death camas is undoubtedly the most important. This plant is found in every county of the State, and on every stock range which we had opportunity to visit. It usually occurs in great abundance in the localities where it is found, and these localities are, unfortunately, as a rule, moderately moist places, where the grass starts earliest in the spring. Another reason why this plant has to be considered the most important poisonous one concerned in cases of spring poisoning is that it starts up very early, usually somewhat in advance of the native grasses. A third reason is that its leaves are narrow and resemble grass leaves, though at the same time slightly thicker and more succulent than grass. These

[1] Under the name death camas we mean to include those Montana forms which for many years have been known as *Zygadenus venenosus*. These have recently been separated into several new species, which were described by Dr. P. A. Rydberg in the Bulletin of the Torrey Botanical Club, vol. 27, pp. 533 to 536, 1900. Our specimens were identified by Rydberg as the species which he has named *Z. gramineus* and *Z. intermedius*. Another authority to whom the specimens were submitted was of the opinion that our specimens belong to a single species. It is quite possible that they are distinct from *Z. venenosus*, but they have not been so considered in making up our notes.

facts, combined with the fact that all parts of the plant are poisonous, make it apparent that in death camas the stockman has a dangerous enemy.

The preferred habitat or location in which the death camas usually grows is the familiar shallow ravine, or "coulee," which occurs in large numbers on the sides of foothills and mountains and upon the plains. So far as our observations go, the death camas does not grow in the driest situations of the level plain. It often grows abundantly, however, on high bench lands, in the shallow depressions found in such locations. After a little experience in the study of the habitat of this plant, one can detect at long distances the particular places in which it is likely to be found.

In Montana the death camas grows at altitudes varying from 1,900 to 8,000 feet, or, in other words, at all altitudes at which sheep are grazed in the State. Ordinarily the death camas does not grow along banks of streams, or in swampy places. It may be said to prefer localities in which a moderate amount of moisture is found as the result of slow seepage from the surrounding country. It is even more abundant on pasture lands in Montana than is the purple larkspur (*Delphinium bicolor*). On many ranges one could not walk ten feet in a straight line anywhere without tramping upon at least a half dozen of these plants.

As already indicated, death camas, although limited in its distribution to particular localities on the range, nevertheless occurs in great abundance in these localities. It would, therefore, be an easy matter for sheep, in a short time, to find and eat a sufficient number of death camas plants to produce fatal results. In collecting material for feeding experiments, we dug up 250 in the course of a half hour, and it is quite possible that a sheep might eat the plant even more rapidly in localities where it was especially abundant.

HISTORY AS A POISONOUS PLANT.

The earlier explorers of the Western, and especially of the Northwestern, United States frequently mention the poisonous character of the bulbs of one or the other of the various species of Zygadenus, and refer to them as *poison camas* or *poison sego*, in order to distinguish them from bulbs of two other groups of plants, Quamasia and Calochortus, which were commonly known as camas and wild sego, and were much used for food both by the Indians and by travelers.[1] Accounts of the poisoning of stock from eating the roots and leaves of various species have but recently been sent in to this Department. These were from northern California, Nevada, Oregon, Washington, Utah, Idaho,

[1] The Ogallala Sioux Indians of South Dakota call the plant *peji wakan*, which, being interpreted, means "mystery grass." The real significance of the name is not known.

and Montana, and from as far east as South Dakota. Our attention was particularly called to the abundance and wide distribution of *Z. venenosus* in Montana, and to its fatal effect upon stock, by Mr. Thomas B. Magee, Browning, Montana. Prof. F. H. Hillman, of the Agricultural Experiment Station of Nevada, has called attention in two short newspaper bulletins to the poisonous nature of the wild sego (*Z. paniculatus* S. Wats).

It is impossible to state definitely whether the parts of the plant above ground or the bulbs are responsible for the most cases of poisoning. Feeding experiments show conclusively that both the leaves and bulbs are poisonous. Apparently, however, the bulbs are more actively poisonous than the leaves. Whether the sheep eat the bulbs of death camas or not, depends almost entirely on the condition of the ground in each individual case. If the ground is at all dry, or only moderately moist, it is absolutely impossible for sheep to pull up the bulb with the stem. We had experimented with hundreds of death camas plants for the purpose of determining this point, and had come to the provisional conclusion that it is impossible to pull up the bulbs with the stems. In collecting some plants immediately after a heavy rain storm, however, it was found that the bulbs could readily be pulled through the soft ground. About three out of five plants pulled in the ordinary manner came up with the bulbs attached.

During the season of 1900, sheep died from eating death camas at various dates in the month of May and in the earlier part of June. The earliest date was April 25, and the greatest amount of poisoning occurred between May 5 and May 20. From notes made in the field it appears that 636 sheep died during the season of 1900 from the effect of eating Zygadenus, while the total number poisoned by this plant was 3,030. About 21 per cent of the number affected died, while the remaining 79 per cent recovered. This death rate may be slightly lower or higher than the average rate for this plant, direct observations on this point being limited to this single year. The figures as given are based on the death or recovery of adult sheep, and do not include fatalities among lambs. The death rate among lambs was in many instances considerably higher than that of the adult sheep, and this observation applies to lambs which had not begun to eat grass or other plants, but which were poisoned by the ewe's milk. It is of interest to observe that a considerable number of lambs died from the effects of the milk of ewes which were themselves only slightly affected by the death camas. The death rate is, therefore, in reality slightly higher than the figures already given would indicate, for the reason, as already mentioned, that deaths among the lambs were not included in the figures, and for the further reason that the death of an ewe at a time when the lamb is not older than 2 weeks means the ultimate death of the lamb. It is the general observation of sheep men that

lambs seldom begin to eat anything before the age of 1 month, and that they are unable to make a good growth if deprived of the mother's milk before the age of 3 months. The death rate among sheep from eating Zygadenus varied to a considerable extent in different bands; for instance, in one band 2,000 sheep were poisoned and 100 died; in another 200 were poisoned and 90 died, while in a third 100 were poisoned and 48 died. It will thus be seen that the death rate varied from 5 to 48 per cent.

EXPERIMENTS.

In order to ascertain the approximate and relative weights of the bulbs and the leafy tops at flowering time, five fresh medium-sized plants were secured June 6. The total weight of these was 32.7 grams. The five bulbs, including 1½ inches of the stem, weighed 15.2 grams, while the remainder weighed 17.5 grams. The average weight for the plant was therefore about 6½ grams, of the bulb 3½, and of the leaf and floral parts 3½ grams. These bulbs were not bitter or repulsive to the taste. Bulbs collected in other parts of the State were quite bitter, especially after a few moments' chewing. It is possible that the taste varies with the stage of growth and the locality. The leaves of the flowering plants are bitter, and are probably on this account generally refused by animals. Several attempts were made to persuade horses to eat a single spray of the leaves, but always without success. Only once did one allow the plant to get into its mouth, and then the leaves were concealed in a large bunch of fresh lupine leaves.

A supply of plants gathered on the evening of May 22, when the flowering stem was still crisp and in bud, was kept turgid over night and then separated into two portions—the well-cleaned bulbs, including about an inch of the stem, which weighed 45.6 grams, and the tops, which weighed 55.5 grams. These were ground separately in a sausage mill and then macerated for about an hour with about 100 cubic centimeters of lukewarm distilled water. Both leaves and roots had a decidedly soapy feeling when mashed up with water in the hands. The pure juice was distinctly irritating when left on the hands for several minutes. The aqueous extract of the leaves was of a clear green color, that of the roots turbid and milky. Both were strained through a linen sack and diluted to 110 cubic centimeters.

Experiment 1.—On May 23, at 2 p. m., 1 cubic centimeter of the leaf extract was injected hypodermically into a rabbit weighing 1¼ pounds. At the end of fifteen minutes there was a decided appearance of uneasiness, the breathing was shallow, and the head moved rythmically, as if the animal were dizzy. Very shortly afterwards the animal fell over in a convulsive fit and then ran forcibly into a wall, thus showing that its eyesight was affected. The breathing speedily

became irregular, but the heart beat was about normal. The principal poisonous action was undoubtedly on the lungs. The hind legs were paralyzed, and soon the animal became entirely motionless, as if narcotized. It was sensitive to needle pricks, but would permit its hind legs to be placed in unnatural positions. The heart action was good during most of the time. The breathing gradually improved, but the rabbit remained motionless for several hours. Complete nervous prostration was apparent throughout the whole of the next day, the animal appearing as if narcotized. It ate no food, and died during the next night.

Experiment 2.—One cubic centimeter of the same leaf extract previously used was administered on May 22, at 4.10 p. m., subcutaneously to a 2-pound rabbit. The first symptom, a marked choking action with an oft-repeated backward motion of the head, appeared at 4.27. At 4.35 it was noticed that the breathing was irregular and slow, and that the animal was very much disinclined to move. At 5 the breathing was still very much impaired, but the heart action was good. The rabbit had been motionless since 4.35. At 6 it was reported to be in nearly the same condition, and on the next morning the recovery was practically complete.

Experiment 3.—One cubic centimeter of the root extract was administered hypodermically to a rabbit weighing about 2 pounds, on May 22, at 4.45 p. m. At 5 there was a slight throbbing or dizzy motion of the head. At 5.2 it was walking about in a lively manner, but with a peculiar ambling gait, the fore leg having been partially paralyzed. This was continued for about half an hour, the animal being not at all comfortable. At 6 it was reported to have been in a fair way to recovery. During the night it made its escape from the pen, and could not subsequently be recovered.

Experiment 4.—Two cubic centimeters of the leaf extract was injected hypodermically into a 2-pound rabbit May 23, at 11 a. m. At 11.9 the choking began, and a little saliva began to run from the mouth. At 11.15 the breathing was irregular and slow, the animal having moved but little. At 11.17 it had spasms, falling backward and sidewise. At 11.20 it had scarcely enough energy to keep its nose off the floor or to stand. At about 11.27, while dozing, it fell backward in a spasm and lay prostrate on its stomach, with its head sidewise on the floor. Its hind legs were beyond control, its eyes were rapidly losing their luster, and it was gasping for breath. Another spasm occurred at 11.36, which was followed by gasping. The respiration was, on the whole, very shallow. At 11.40 the rabbit was not sensitive to needle pricks. There was more gasping and another spasm. Two minutes later the pupils became contracted, and the rabbit died after three minutes.

The post-mortem examination made immediately after death showed

that the heart was full of dark, unaerated blood and that the lungs, especially the left one, were also badly congested. The liver was darker than usual, but the other organs were in good condition.

Experiment 5.—Five cubic centimeters of the same leaf extract used in the preceding experiments was fed May 23, at 2.4 p. m., through a rubber tube to a rabbit weighing 1 pound 10½ ounces. At 2.30, after having been running around as usual, it became noticeably quieter and showed a little irregularity of breathing. At 2.54 it was a little ill at ease. At 4 it appeared much brighter. Ten cubic centimeters more of the solution was then administered. It rested quietly the remainder of the day, being much disinclined to move yet not strikingly ill at ease. The experiment was unfortunately terminated by the escape of the rabbit during the night.

Experiment 6.—On May 25, 11.55 a. m., 15 cubic centimeters of the water extract of the leaves was fed to a rabbit weighing 1 pound 12 ounces. At 12.5 the first sign of uneasiness was exhibited in a peculiar chewing motion of the mouth, which seemed to indicate burning pain in that organ. This was followed by prolonged drowsiness, with an occasional rapid shaking of the head. There was no strongly marked difficulty in the breathing. At 1 the animal was walking around freely and eating, but it continued the head movements and its ears were depressed, showing that there was still considerable discomfort.

At 1.15 15 cubic centimeters more of the extract was administered. At 3.10 and 3.30 the rabbit appeared well, and as it was sufficiently active to play with a piece of paper at the latter time the experiment was discontinued. The solution was too dilute for satisfactory feeding experiments, the capacity of the stomachs of the rabbits used in the experiment being insufficient for a much larger dose.

Experiment 7.—Fifty grams of the fresh leafy tops, about half the flowers of which had expanded, was offered at 5.25 p. m., June 6, to a rabbit weighing about a pound. As the animal was hungry, it ate some of the plants, flowers and all, quite readily, even though they were dry and uninviting in comparison with younger plants not yet in blossom. At 6, when the residue was weighed, only 13.1 grams had disappeared, so that this was the amount eaten. As, however, the first symptoms, which came on at 6, were strongly characteristic of the poisonous substance contained in the plant, it is quite probable that most of the 13.1 grams was eaten very shortly after 5.25 p. m.

The first symptom was a pose much like that of a person who is about to sneeze, the animal resting on its hind feet with its front feet held close together in front of its face. Instead of sneezing, however, it threw its head backward again and again, often nearly losing its balance in so doing. There was an apparent dizziness, and the eyesight was slightly impaired, for it once ran into the side of the cage. This was not, however, a marked symptom. The animal grated its

teeth and was uneasy and restless. The pupils were considerably enlarged. At 6.7 a partial paralysis of the respiration was noted. The breathing was extremely slow and there was considerable choking. At 10.10 the next morning, June 7, it ate food, although sparingly. It would walk and run of its own accord and in other ways it afforded proof that it had very nearly recovered.

At 2.40 the same day 50 grams more of the fresh leaves was offered to the same rabbit. It ate rapidly at first, but soon became dissatisfied, and although very hungry, it refused to eat more. The exact amount eaten was not determined, nor many of the symptoms noted on account of an accident. A difficulty in the respiration was observed at 2.55, and Mr. Cockrell, who was watching the animal, thought that the respiratory symptoms were more pronounced after the animal had taken a good drink of water. This trouble was apparent throughout the day. Twenty-five grams of fresh leaves of flowering plants was offered to the same rabbit at about noon on June 8. The weight of the leaves left uneaten when compared with the weight of a check subjected to influences even more favorable to evaporation indicated that none were eaten. No further effects were noted except the continued defect in respiration, but the rabbit died during the night, probably from the combined effect of the several feedings.

Experiment 8.—Three hundred cubic centimeters of a water extract, representing 300 grams of the fresh flowering tops and leaves, was fed to a sheep weighing about 65 pounds at 3.15 p. m. June 12. No effect whatever was noted up to 8 p. m. nor on the following day.

Experiment 9.—The strongly expressed residue from the extract used in the preceding experiment was allowed to stand over night in such an amount of 50 per cent alcohol that after a very slight dilution on the same day 1 cubic centimeter represented 1 gram of the fresh plant. One and one-half cubic centimeters, representing 1½ grams of the fresh plant, was administered hypodermically June 12 to a 40-ounce rabbit. This amount, although small, had a very marked effect, but was not fatal. The result warranted the institution of the two following experiments, which were made with the same extract.

Experiment 10.—Three hundred cubic centimeters of the 50 per cent alcoholic extract used in the preceding experiment was fed at 12.21 p. m., June 14, to a sheep weighing about 50 pounds. Disregarding the general symptoms due to alcohol, which were also observed in another sheep that received an equal amount of 47 per cent alcohol at the same time, the prominent characteristic effects were as follows: At 2.30 there was considerable frothing of green saliva at the mouth, which was accompanied by a gurgling of the throat and very labored, irregular breathing. There were but 12 inspirations a minute and sometimes two attempts at a single one. The pulse was about 160 a minute and strong. At 3.24 the sheep was becoming conscious, but

was unable to rise, and it remained in this condition until after 7 p. m. The gurgling, labored respiration and sighing continued throughout that time, but the frothing ceased after an hour or so. The rectal temperature at 5.25 was 101.8. The animal had sufficiently recovered by the next morning to go out and graze with the remainder of the little band of which it was a member.

Experiment 11.—Precisely the same amount of the same extract used in Experiment 10 was fed in the same way at 2.55 p. m. to a sheep weighing approximately the same, but before withdrawing the tube 25 cubic centimeters of a solution containing 1 per cent each of the permanganate of potash and sulphate of aluminum was poured into it and this was washed down into the stomach with water. A deep sleep soon came over the animal from which it did not awaken until after night, but although watched very carefully until past 7.15 p. m. it did not exhibit any of the symptoms recorded for the previous experiment.

Experiment 12.—On May 21 two healthy sheep were placed in a corral and fed, respectively, 30 plants of death camas without the bulb and 20 with the bulb, or approximately 105 grams and 220 grams of these materials. These two sheep were not hungry and would not of their own accord eat the death camas when placed in a box near them. When the sheep were held, however, and the death camas placed in contact with their lips they ate it readily. One hour later symptoms of poisoning began to be manifested which were exactly identical with those previously observed in the field. The quantity of death camas fed to these two sheep was not quite sufficient to cause death, although they were seriously poisoned and required three days for a complete recovery from the effects.

Experiment 13.—On June 8 two other sheep were fed each 40 death camas plants with bulbs, or approximately 440 grams. The same symptoms were manifested in a more violent form, and both sheep died after the lapse of five and six hours respectively. The death camas plants fed to both these sheep were in full flower. At the time of this experiment the plants at the lower altitudes were already in seed and the leaves and stems were yellow and shriveled, but the plants used were collected at an altitude of about 6,000 feet, where they were in the prime of flowering. The plants employed in both experiments were therefore as nearly as possible in the same stage of growth. As these experiments were conducted in the field the means were not at hand for weighing accurately. The weights as given above are calculated from average weights as previously determined. It would therefore appear that the fatal dose for sheep is between one-half pound and 1 pound.

Experiment 14.—Remedies which were tried in this and the following experiment included hypodermic injections of strychnine in one-

twentieth, one-tenth, and one-fifth grain doses, hypodermic injections of atropine in one-sixtieth and one-thirtieth grain doses, and solutions of potassium permanganate. The strychnine and atropine were given by means of the ordinary hypodermic syringe in different parts of the body, usually behind the front leg in the bare area of skin at that point. The atropine was given both alone and with morphine, as is customary in human practice. The potassium permanganate was given in 4-grain doses, and each dose contained also 1 grain of aluminum sulphate. Both these substances were pulverized and dissolved in about a pint of water. Doses were given both as a drench and by means of direct injection through the body wall into the stomach. In some cases also the sheep were allowed to drink the solution. The results which were obtained did not indicate any advantage in favor of any method, for in all cases the solutions seemed to be equally effective, whether given as a drench, injected directly into the stomach, or as a drink. For injecting the solution directly into the stomach a large aspirating syringe was used. The solution when applied in this way was kept in a bottle connected by means of a rubber tube with the syringe. An ordinary trochar and canula were used for penetrating into the stomach. By means of this apparatus a half pint of the solution could be very quickly pumped into the stomach. The process requires, however, rather more time than the drenching method, and since the action of the solution was no more effective when injected directly into the stomach than when given as a drench, the drenching method will probably be preferred by stockmen as being shorter and more convenient.

The first experiment with these remedies and methods was made on May 15, 1900, on a sheep range near Great Falls. A number of sheep had been poisoned by Zygadenus two days previously. About 20 of the most severe cases had been hauled into a covered shed. Here the sheep were lying upon their sides in the condition of complete paralysis referred to in the description of the symptoms of poisoning from this plant. Five of the sheep were given hypodermic injections of strychnine, 5 others similar injections of atropine, 5 others solutions of potassium permanganate, and the remaining 5 were left without treatment. Of the 5 sheep which were treated with potassium permanganate 2 were drenched, 2 others received direct injections into the stomach, and 1 was allowed to drink the solution from a small bucket. Of the 5 which were treated with strychnine, 2 sheep received one-twentieth grain, 2 one-tenth grain, and 1 one-fifth grain. Of the 5 which were treated with atropine, 2 received one-sixtieth and 3 one-thirtieth grain. All these sheep were examined three hours later, when it was found that the 5 which had been given potassium permanganate were in a much improved condition and were able to walk. The herder, who watched the sheep during this period, stated that

some of these 5 sheep had got up of their own accord, walked about for a few minutes, and then lain down again. The breathing of these sheep was much improved and regurgitation through the mouth and nostrils had ceased. The 5 sheep which were treated with strychnine were in a slightly better condition than before the treatment. Some improvement was noticeable in the pulse and respiration. None of them, however, could stand on their feet even when placed in that position. Of the 5 sheep which were treated with atropine, 2 had died, and the other 3 were not improved in their condition. Four out of the 5 sheep which were untreated were apparently in the same condition as when previously inspected, while the fifth had died. The 4 others died later. These experiments indicate that potassium permanganate is an efficient antidote for poisoning by death camas. Atropine, on the other hand, seems not to be indicated in these cases, while strychnine seems to have only feeble power of antagonizing the action of death camas. All of the sheep which were treated with atropine, and all but 1 of those treated with strychnine, ultimately died, while the 5 sheep which received potassium permanganate made a complete recovery.

To appreciate fully the force of the evidence, it should be considered that at the time when the three remedies mentioned above were applied the sheep were in a hopeless condition. Both the herder and the foreman gave it as their opinion that all of the 20 sheep would die if left to themselves. They all had been in a condition of complete paralysis for a period of from twenty-four to thirty-six hours. Potassium permanganate was used in these experiments as a chemical antidote on account of its oxidizing power, and a pronounced effect in counteracting the physiological action of the death camas was not expected. It was hoped that if given during the early stages of the poisoning while the most of the poisonous plant which had been eaten was still in the first stomach, the poisonous principle might be destroyed by its action before being absorbed into the blood. Not enough was known concerning its physiological action to lead one to expect that it would serve as a physiological antidote. The result would seem to indicate, however, that the physiological action of potassium permanganate is to some extent antagonistic to that of death camas, and that at the same time its chemical action brings about prompt and complete destruction of the poisonous principles of this plant. In the cases of poisoning now under discussion it is evident that a considerable quantity of the poison must have been dissolved and absorbed into the blood at the time when the potassium permanganate was given, and this portion of the poison it was evidently impossible to destroy by any chemical in the stomach. If it should prove on further investigation that potassium permanganate has no physiological action antagonistic to that of death camas, we must

apparently conclude that sheep can recover from very severe cases of poisoning by this plant, provided such quantity of the plant as still remains in the stomach is rendered nonpoisonous by chemical means, such as the use of potassium permanganate.

Experiment 15.—On subsequent dates in the month of May potassium permanganate was given to 15 adult sheep and 20 lambs which had been poisoned by eating death camas. In all cases the animals were much improved by this treatment within two hours and the majority of them recovered ultimately, although reports have not been received on a few of the lambs. The lambs which received this treatment were from two weeks to one month old, and did not as yet eat any grass or other plants. The poison which they received was, therefore, contained in the mother's milk. The lambs were given from one-half gram to 1½ grams of the potassium permanganate, according to the size. The solutions were administered both as a drench and by direct injection into the stomach. The treatment was given in most cases immediately after the lamb had been suckled by the ewe. The potassium permanganate seemed to have a decidedly beneficial action in checking the digestive disturbances produced by the action of the death camas in the lambs. The stiffness of gait and other irregular muscular movements were also corrected within a few hours.

SYMPTOMS AND EVIDENCES OF POISONING.

The symptoms were remarkably uniform in the large number of cases observed, and the following description should enable any sheep raiser to recognize the cases of poisoning by death camas. The first signs of poisoning are a certain uneasiness and irregularity in the movements of the sheep. These irregularities rapidly become more and more pronounced, accompanied by incoordination of the muscular movements, spasms, and rapid breathing. Although sheep are highly excited under the influence of Zygadenus poisoning, the cerebral symptoms seldom constitute a condition of frenzy. It was readily observed that until a few minutes before death ewes were able to recognize their lambs, and indicated in other ways that they were not in any sense crazed. The later symptoms were those of complete motor paralysis, combined with an exceedingly rapid and shallow breathing and a frequent weak pulse. The duration of these different stages of the poisoning varied to a considerable extent and depended entirely upon the amount of death camas which the sheep had eaten. In cases where large quantities had been eaten the different symptoms succeeded one another rapidly, the spasms and labored breathing were very noticeable, and death resulted within from one to three hours after the first manifestations of poisoning. In many cases, however, the sheep passed through the first symptoms slowly, and after about

ten or twelve hours became unable to walk, stand, or even raise their heads, remaining in this condition of complete muscular paralysis for a period of from twenty-four to forty-eight hours. During this time the sheep, as just indicated, lay flat upon the side and did not move any voluntary muscle. The breathing was in these cases so shallow that it was scarcely perceptible and the sheep appeared to be dead. A small percentage of the sheep recovered after being in this condition for a few hours, but very few ever got upon their feet after being paralyzed for twenty-four hours. Careful post-mortem examinations were made on about 40 sheep which had died from eating death camas. The lungs were in all instances much congested and heavy with blood, being in a so-called hepatized condition. There were no lesions in the membranes of the brain, and for the most part no congestion of them. In a few instances of cases of long duration there was a slight congestion of the cerebral membranes. In cases of adult sheep the effect upon the digestive organs was not marked. There was usually to be observed an increased salivation and a regurgitation through the mouth and nostrils. These last symptoms were present in nearly all cases from the first to the last stages. In lambs the symptoms which have been described for adult sheep were present, with the addition of pronounced digestive disturbances. The symptoms appeared in the lamb soon after their manifestation in the mother, and the poisoning usually ran a more rapid course in the former than in the latter. The digestive disturbances in the lambs were frequently of an acute nature, usually assuming the form of painful and violent enteritis and dysentery, from which the lambs died in the course of a few hours. In cases where the ewes ate only a small quantity of death camas and were only slightly affected by it, their lambs exhibited much milder symptoms. The lambs thus affected could be readily recognized by their stiffness of gait and their inability to keep up with the herd.

The symptoms which were produced experimentally by feeding the death camas to sheep, were identical with those which have been mentioned as characterizing natural poisoning by this plant. Such experiments, however, were confined to dry sheep, so that no opportunity was had of observing the symptoms of experimental poisoning in lambs.

As happens in connection with a number of poisonous plants, the majority of sheep which were poisoned by death camas were yearlings and two-year-olds. Perhaps sheep form more fixed and settled habits of feeding as they grow older, or it is barely possible that they learn by experience to avoid injurious plants. There was no indication that ewes with lambs at their sides were any more apt to eat death camas than were dry sheep.

In conversation with stockmen attention was frequently called to the

fact that in cases where a large number of sheep were poisoned at the same time by eating death camas, a striking variation was noticed in the length of time required for the development of the symptoms of poisoning in different sheep. This observation seems especially interesting in view of the fact that ordinarily a band of sheep is moved to another locality as soon as symptoms of poisoning are noticed. Sometimes the band is immediately driven to a corral. Even under these circumstances the time at which the first symptoms of poisoning appear may vary from one to five or more hours. The only reasonable explanation which suggests itself is to be found in the anatomy and habits of the sheep. As is well known, the first stomach of a sheep is capable of containing a large quantity of material. It is another fact of everyday observation that sheep are ordinarily not contented, and do not lie down for noonday rest until this stomach is completely filled. It will readily be understood that a given quantity of a poisonous plant eaten along with a much larger quantity of grass, would naturally come to occupy different positions in the stomach in different sheep. Evidently the sheep is not affected by a poisonous plant until its substance is dissolved and absorbed into the general circulation. It might well happen that a quantity of the poisonous plant, sufficient to cause death, could be in the center of a great mass of other material found in the first stomach. In such a position the poison would certainly not affect the sheep, and it would be evidently impossible to predict how soon it might come to lie against the wall of the first stomach, or how soon it might be taken up, masticated, and swallowed into the digestive stomach. The time at which this takes place will naturally vary in different sheep, and consequently the time at which the first symptoms of poisoning are manifested will vary in the same manner. In the case of animals which have only a single comparatively small stomach, as in the horse and pig, it would be manifestly impossible for so long a time to intervene after eating poisonous plants before the symptoms of poisoning are manifested.

From observation and experiment, the evidence establishing the poisonous nature of death camas seems quite conclusive. In making post-mortem examinations of sheep which had died with the above-mentioned symptoms the stomach contents were carefully studied with the result that the leaves, flowering stems or bulbs of death camas were found in every case. Sheep which were seen eating the plant when feeding at leisure upon the range showed within a few hours the symptoms described. In looking over the ranges where the sheep had been poisoned death camas was found growing abundantly in the exact localities where the sheep were poisoned. A study of these localities showed that death camas had been eaten extensively there and careful investigation failed to disclose the presence of any other plant which

can reasonably be suspected of being poisonous, with the single exception of the purple larkspur. This latter plant, however, had not been eaten by the sheep in localities where the death camas was abundant. Besides this evidence, obtained under natural conditions, experimental proof was obtained by collecting death camas and feeding it and its extracts to sheep and rabbits. The symptoms produced by this experimental poisoning and those which were observed in natural cases were identical.

During extended trips over different portions of the State many localities were examined where it was said that poisoning uniformly occurred if sheep were allowed to range there during the month of May. The death camas was found to be the only suspicious plant which grew in abundance in all such localities. A considerable number of places were visited where poisoning of sheep in the spring had occurred to such an extent for a number of years that these parts of the range had had to be abandoned during that season, and sheep were only allowed to graze there during the late summer and fall. In all such places the death camas grew abundantly and was the only plant which could have caused serious poisoning.

REMEDIAL AND PREVENTIVE MEASURES.

In cases of poisoning by death camas, a solution containing equal weights of permanganate of potash and sulphate of aluminum should be administered at once according to the directions already given.[1]

The only practicable preventive measure which can be suggested is to determine the localities where the plant is most abundant from year to year and to herd the sheep away from such areas during the early spring, when the plant is succulent and most tempting. In order to do this, it is necessary for each sheep herder or owner to become familiar with the plant in all of its stages of growth.

SUMMARY.

Death camas is an extremely common and widely distributed plant in Montana.

The bulbs have long been suspected in Montana and elsewhere of being poisonous to stock and to human beings.

Our observations showed that the plant is frequently eaten by stock, especially by sheep, with fatal results in a large percentage of cases.

Our experiments with rabbits and sheep demonstrated that the leaves as well as the bulbs are poisonous in moderate quantities, both rabbits and sheep having been killed by eating the plant.

Experiments with various remedies indicated that permanganate of potash was the most effective antidote.

Sheep should be herded away from this plant in early spring.

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TALL LARKSPUR.

(*Delphinium glaucum* S. Wats.)

DESCRIPTION, HABITAT, AND DISTRIBUTION.

The common tall larkspur (Pl. II) of Montana (erroneously called aconite) is a simple-stemmed perennial, 4 to 7 feet high, which is smooth throughout and covered during most of its growth with an easily erasable white coating like that commonly observed on ripe plums. Before flowering time the succulent basal leaves become long-stemmed and form tufts which about the 1st of June are a foot or so in height and of nearly the same diameter. In general the lower leaves are large and geranium-like, being broadly circular in outline, and 4 to 6 inches in diameter, with broad segments having lance-shaped extremities; the upper floral leaves lance-shaped, simple, and very much smaller. The numerous flowers are of a pale-blue color, and are arranged in long slender terminal racemes. The seed capsules are three-lobed and smooth, the seeds black.

This species of larkspur is easily distinguished from the purple larkspur, which is the other common species in the State, by the great difference in the shape of their leaves and the color of their flowers. The tall larkspur has the flowers considerably smaller than those of the purple larkspur and arranged in a long, close terminal spike. The plant with which this species is most likely to be confused is the wild geranium (Pl. III), but the danger is confined to the early part of the season before the flowers are developed. After the flowers of the larkspur and geranium appear, the two plants are easily distinguished by the casual observer. In the earlier stage some help may be obtained in distinguishing between them by carefully observing the appearance of the leaves. Those of the tall larkspur are almost, if not quite, perfectly smooth, while those of the geranium are always more or less hairy. Although these two plants grow in the same situations and are frequently found intermingled, a little experience with special attention devoted to noting the leaf characters will enable one to distinguish them at a glance, even from a considerable distance.

The tall larkspur has a rather wide distribution in the State. Its preferred habitat seems to be rich and moderately moist half-shaded localities, especially on slopes of foothills or mountains and among underbrush along streams. It is found in valleys and up to a height of 9,000 feet. When growing in the higher altitudes, the color of the flowers is usually a much darker blue than when growing in lower altitudes, and the height of the plant is less. Otherwise no striking differences are noticed due to situation or altitude. The tall larkspur grows very abundantly in the Big Belt and Little Belt Mountains, Big Snowy, Crazy, and Bridger Mountains, Gallatin Range, Absaroka,

Bear Tooth, Castle, and Rocky Mountains, Mission Range, and Bitter Root Mountains. The distribution of this plant so far as observations of the season of 1900 go, includes the following counties: Flathead, Teton, Ravalli, Lewis and Clarke, Fergus, Meagher, Madison, Jefferson, Gallatin, Park, Sweet Grass, Carbon, and Deerlodge. It is widely distributed in mountain regions from California to Alaska. But although this plant is found in a large number of counties of the State it is far less abundant than the purple larkspur, the localities in which it is found being as a rule far more restricted. The purple larkspur is to be found in almost every locality where the conditions are favorable to its growth, which is far from true of the tall larkspur.

HISTORY AS A POISONOUS PLANT.

The tall larkspur appears not to be eaten by sheep. All cases of poisoning from this plant observed in Montana during this year and previous years have been among cattle. As already indicated, sheep are not driven to the mountain ranges until about the middle of July, and at this season the tall larkspur is altogether too large and coarse for their consumption. It is well known, on the other hand, that cattle will feed on much coarser forage than sheep, and at the same time they are allowed to run on the high ranges in the early spring. In Montana the light green tufts of leaves of the tall larkspur first become conspicuous about the last of April or the first of May, and the flowers begin to open about the middle of June. This fact is significant for the reason that light falls of snow often occur in the larkspur belt as late as the first week in June, and, since there is then no other verdure in sight, the uncovered portion of the larkspur is in a high degree tempting to stock, all the more because it is succulent. The danger is increased by the fact that at the time of snow falls cattle seek the shelter of creeks where the larkspur is more abundant and most advanced in growth. At this period, moreover, the leaves are, as we can testify from personal observation, very bitter, and they are probably then more poisonous than at any other stage of growth. The older ones, as is also the case with the blue larkspur, are not so bitter. The plant is recognized by cattlemen as dangerous to cattle from May until about the middle of June. Mr. Vard Cockrell informs us that on his range in the lower basin of the Gallatin it is the sole duty of one man during this period to keep his cattle away from the broken mountainous regions where this larkspur abounds.

In response to a communication from the Department Mr. E. C. Alderson, of Bozeman, Mont., a man of wide experience as a guide in Montana, states that about the middle of July and later he has observed that horses will sometimes walk out of the beaten trail to nip the tops of the flowering plants, and Dr. F. W. Traphagen, professor of chemistry at the Montana Agricultural College, informs us that he has seen

TALL LARKSPUR (DELPHINIUM GLAUCUM).

WILD GERANIUM (GERANIUM VISCOSISSIMUM).

a horse browse on the flowering plants in August for fully ten minutes at one time. In such cases the tall larkspur may sometimes be eaten, but as a rule stock do not manifest any special fondness for it. On both slopes of the Big Belt Mountains the tall larkspur grows abundantly, and cattle and horses range over these areas during summer and autumn. Although cattle are sometimes killed by eating the plant during early summer on the lower slopes, especially near Townsend, search was made in vain for any evidence of the plant having been eaten in these localities during late summer and autumn. It was noticed that while the grass and other plants growing among the stems of tall larkspur had been eaten the larkspur was left standing. On the other hand, there are cases on record where cows have been killed by eating the dry tops of tall larkspur in September, at which time nearly all the leaves have disappeared and the seeds which, judging from analogy with other species, probably contain a poisonous alkaloid, remain in the ripe capsules. We have heard of no observations showing that the plant has ever killed horses nor on the other hand that the leaves have ever been eaten by them or other stock to any extent with impunity before flowering time. A few persons believe, however, that the plant is not dangerous to horses or cattle except when wet or when snow is on the ground. It is easy to understand why more stock should be killed by it when snow covers almost every other plant, as it often does both in spring and autumn; but why it should prove more fatal when wet is very difficult to understand. The roots are too woody to be eaten.

Although many cattle are undoubtedly killed by eating the tall larkspur there are few recorded instances of such poisoning. One reason for this, however, lies in the fact that cattle, unlike sheep, being left to the care of themselves on wide ranges are, when poisoned, more frequently found dead than alive, and hence the symptoms, which furnish the most convincing evidence in tracing out any case of poisoning, remain unrecorded. The plant has been received from Livingston, Bigtimber, Cherry Creek near the Madison River, and Sedan, accompanied by a statement that it caused the death of cattle, and in the Gallatin Basin the tall larkspur has for many years been recognized as the cause of more or less serious losses of cattle in the spring.

EXPERIMENTS.

The following experiments were primarily conducted with the object of determining whether the immature plants are poisonous or not and, if so, of finding an antidote. As, however, no previous records of experiments or observations on the plant were found showing the characteristic symptoms of poisoning by it in stock some notes were made in this line also.

Experiment 1.—The extract used in this experiment was made by Irvin Cockrell from dried roots collected during the preceding season.

These were ground into an impalpable powder and 50 grams was percolated with 200 c. c. of 50 per cent alcohol and then filtered.

Ten cubic centimeters of this filtrate, representing 2½ grams of the dried root, was fed at 2.40 p. m. to a white rabbit (A) weighing 35 ounces. The same amount of 50 per cent alcohol was fed five minutes later to another rabbit (B) of nearly equal weight, the object being to compare the symptoms produced by the alcohol with those produced by the extract and to note the difference. The symptoms thus obtained are not of course identical with those which would be produced by the poison alone, but they show some of the same characteristics, although the alcohol probably lessens their intensity at certain stages, as Dr. Wilcox has shown to be the case in poisoning from the blue larkspur.

Both of the rabbits were somewhat similarly affected by the alcohol. In both instances the voluntary muscles were more or less paralyzed, especially at first, the disinclination to move being most apparent in the check B, to which the alcohol was given. During the later stages, however, it appeared stronger but more stupid. It was also much less alarmed than A. Its heart action was stronger and less rapid and it did not show the peculiar spasmodic twitching of the muscles all over the body which was so characteristic of the rabbit to which the larkspur extract was given. At 3.27 it was noticed that A's respiration was not so strong as B's and that it was decidedly wheezy. The spasmodic twitching of the muscles was prominent both before and after this time. The alcoholic symptoms continued in both cases until 5.40, at which time the observations were discontinued. The animals were bright and hungry the next morning.

Experiment 2.—The material for this experiment was obtained from tufts of nonflowering plants a foot high, collected May 26 in rich, moist soil on the northern slope of Bridger Peak at an altitude of about 7,000 feet. While gathering the plant it was noticed that the leaves though succulent were very bitter. This was also noticed in leaves gathered at the same place two weeks later. They were preserved in nearly their pristine condition in a botanical collecting box until May 28, when 50 grams was cut up in a sausage mill and extracted at ordinary temperature over night with 100 c. c. of distilled water. After warming at blood heat for a half hour next day the extract was filtered and was ready for use, while the residue (which was afterwards discarded) was set to soak with 100 c. c. of 50 per cent alcohol.

Eight cubic centimeters of the water extract, representing 4 grams of the leaves prepared from nonflowering plants as described above, was fed to a 26-ounce rabbit on June 1, at 3.3 p. m. It caused labored breathing with wheezing and rapid heart beats, but was not fatal. This was the case also after a second feeding of 10 c. c. given at 4.30

p. m. The rabbit was, however, very unwell for several days afterwards. On June 2 the motion of the head backward and forward, characteristic of the water extract of the purple larkspur, was very pronounced, but neither on June 1 nor June 2 was any spasmodic twitching of the muscles noted. As the rabbit could not, however, be closely observed more than an hour or two during all of that time these symptoms might easily have been unobserved. The rapid but feeble and wheezy respiration, the rapid heart beats, and the evident malaise continued with loss of appetite on the third, fourth, and fifth. On June 6, 14 c. c. more of the same extract, which had as yet shown no signs of molding, was fed, but no additional symptoms were noted on that day. The respiration was extremely rapid (over 110 a minute) and irregular, and the next morning the animal showed a strong disinclination to move even when urged. It also refused to eat. On June 9 it appeared to be quite well. On June 13 it was somewhat droopy, but it eventually recovered.

Experiment 3.—Fifty grams, including the succulent leaves and stems of nonflowering plants collected on Bridger Peak on the morning of June 11, was fed that afternoon, while the plants were still fresh, to each of two rabbits, numbers 28 and 88 respectively, which had been deprived of their breakfasts. A third amount of equal weight was exposed in an adjoining pen in order to ascertain the loss of weight due to evaporation. After six hours the check had lost 30 per cent of its weight. Rabbit number 28 had, during this time, eaten all but 6¼ grams, while number 88 had eaten all but 22½ grams. The actual amount eaten was, therefore, approximately 42 grams and 22 grams. Neither quantity proved fatal. Lack of time forbade any but the most casual observations on these rabbits and no symptoms were noted. Both were bright and vigorous the next day, but number 28, which had eaten the larger amount of leaves, was more easily frightened than usual.

Experiment 4.—Late in the evening of June 12, 1½ c. c. of the expressed juice of the fresh leaves gathered June 11 was given hypodermically to each of two rabbits, but no characteristic symptoms of poisoning were noted, the rabbits appearing but slightly ill at ease the next morning.

Experiment 5.—The extracts used in this and the two following experiments were obtained from a part of the supply of nonflowering plants gathered on June 11 on Bridger Peak, part of which was used in the two preceding experiments. All three of the tests were made on sheep at Bigtimber on June 14.

On June 12, 1,700 grams of the fresh leaves and stems was ground up in a sausage mill, care being taken to save the juice which was pressed out at the same time. The fibrous portion was then placed

in a strong linen bag and subjected to pressure in a filter press, and the juice thus obtained was added to that already saved in grinding, 870 c. c. in all being obtained. Some of this was used in experiment 4.

On June 14, at 8.15 a. m., 400 c. c. of this juice was poured through a rubber tube and funnel into the stomach of a sheep weighing approximately 50 pounds. No symptoms were observable up to 10 o'clock, but the animal was uneasy and slightly bloated. The skin twitched occasionally and the respiration was weaker and somewhat labored, the rate being 24 a minute. The pulse rate was 92. At 10.42 the animal, although a little droopy, would run about readily and did not appear to be uneasy. Four hundred cubic centimeters more of the juice was now fed. At 3.15 there was a slight trembling of the limbs. The animal had been lying down calmly for some time, but was now on its feet and, although somewhat weak, could walk with ease. It remained standing in the same condition for over two hours. At 7 it was resting contentedly without any sign of discomfort, and on the next day it was apparently as well and as active as usual.

Experiment 6.—The residue left after expressing the juice from 1,700 grams of the plants used in the previous experiment was soaked over night in 1,000 c. c. of alcohol, to which 10 c. c. of the dilute acetic acid was added to facilitate the extraction of the alkaloids. One thousand one hundred and thirty-three cubic centimeters of alcoholic extract was obtained the next day by filtration and by strong pressing in the filter press.

Four hundred cubic centimeters of this extract was fed June 14, at 8.53 a. m., to a sheep weighing about 50 pounds. The large quantity of alcohol contained in the extract caused the sheep to stagger to the floor within a few minutes and, of course, produced most of the characteristic physiological effects. By comparison with a check of about equal weight to which the same quantity of 50 per cent alcohol had been given a few minutes before, certain symptoms characteristic of the larkspur were noted. At 9.20 the animal was lying on the floor suffering from an almost complete loss of muscular and nervous energy. The pulse rate was 72 a minute, but the pulse was exceedingly weak. The animal could not raise its head. At 10.20 it was more conscious, but its skin was quivering constantly and was very sensitive to touch. The rate of breathing had increased to 33 a minute, but was very shallow. The pulse rate was not determinable on account of its great rapidity and the constant trembling of the animal's body. At the same time it had gained control over its muscles to such an extent that it could hold its head off the floor for about a minute at a time. It continued in the same condition, but gradually recovering its strength, until 6.30, when it got upon its feet. The trembling and twitching of the muscles ceased to be very prominent at about 3 o'clock, but it was observed in less pronounced form until 6.30. At 5.12 it was but

slightly dizzy and had to a considerable extent regained its bright appearance. The rectal temperature at 5.30 was 102.6°. At 7.15 the sheep was running about the pen restlessly and had a good appetite. On the following day it fed and walked about as usual.

Experiment 7.—At 1.55 on the same day in which the above experiment was made the same quantity of the same extract was fed in the same way to a sheep of nearly the same weight, but within a minute afterwards a dose was given which contained a quarter gram each of potassium permanganate and aluminum sulphate in the form of a 1 per cent aqueous solution. The symptoms subsequently noted, consisting as they did in a deep narcosis only, were wholly attributable to the effects of the alcohol. The animal was watched closely for five and one-half hours, but showed none of the symptoms of larkspur poisoning, and on the following morning it was as well as usual.

Experiment 8.—The only remedy with which experiments were made in the treatment of cases of poisoning from this plant was drenching with a solution of potassium permanganate. The test of the efficiency of this remedy in the case of cattle was not so severe as it was in the case of sheep. Potassium permanganate in doses of 25 grams was given to 4 cattle and all of these animals recovered. The remedy was applied during the incipient stages of poisoning, and therefore before it was possible to know whether or not they had eaten a sufficient quantity of the tall larkspur to produce death. The animals, however, recovered more rapidly than could have been expected without treatment, when it is considered that three others which were not treated died within about six hours after the first development of the symptoms of poisoning. But it is obviously impossible in the case of animals just beginning to manifest symptoms of poisoning to predict whether or not they will die if not treated, unless the identity of the alkaloid is known, the size of the fatal dose, and the amount which has been eaten by the animal poisoned. Naturally these conditions can not be realized in doing field work on plants of which the poisonous principles have not yet been isolated or studied chemically.

SYMPTOMS.

The symptoms of poisoning by this plant may be described as follows: In general, the animals affected manifest symptoms similar to those produced by overdoses of aconite. The first signs of poisoning are usually a general stiffness and irregularity of gait. There is often a pronounced straddling of the hind legs in walking. These symptoms increase in severity until locomotion becomes difficult or impossible, and the animal finally falls to the ground. It usually falls and gets on its feet again a number of times, the muscular movements becoming more and more irregular and incoordinated. At the same time the skin is very sensitive to touch, and the muscles of the sides

and legs soon begin to quiver spasmodically. This a very characteristic symptom, being usually exhibited for several hours. The function of the special senses is seldom impaired, the animal being apparently able to hear and see as well and as correctly as under conditions of health. Although a slight increase in the quantity of saliva is to be noticed in some cases, this symptom is never so pronounced as in cases of poisoning by death camas. During the later stages of poisoning the animal is usually attacked with violent convulsions, in one of which it finally dies. In this respect, also, the symptoms differ distinctly from those of death camas poisoning, which is usually quite without spasms. The digestive functions seem not to be affected by larkspur poisoning. The temperature is lowered slightly during the first stages, in one instance having been as low as 97°. During the later stages the pulse becomes very frequent and the breathing rapid and shallow. The cerebral symptoms are simply those of excitement, and the appetite seems not to be lost until shortly before death.

REMEDIAL AND PREVENTIVE MEASURES.

In cases of poisoning by tall larkspur, permanganate of potash and sulphate of aluminum should be administered as recommended for poisoning by death camas.[1] For counteracting the physiological effects, atropine should be given hypodermically in doses of from ½ to 1 grain for cattle and horses. Alcoholic stimulants and ammonia may be administered to some advantage. To prevent poisoning from larkspur, cattle should be herded away from the localities where it abounds in spring until the danger from early snowstorms has passed.

The distribution of the tall larkspur in Montana is for the most part in such sharply defined and moderate-sized areas that the possibility of exterminating it by digging is not out of the question. For example, in Gallatin County there is a cattle range located at an altitude of about 6,500 feet, in a basin surrounded on all sides by mountains. Cattle have been allowed to graze on this range every season for a number of years, and a greater or less number of animals have died each year from poisoning by the tall larkspur. In 1898, during the early part of June, 40 died from eating this plant, while during the spring of 1900 only 3 were poisoned. A careful inspection of this range showed that the tall larkspur was entirely confined to a few areas of small size. It is believed that it could all be completely exterminated by twenty-five days' work with a weed digger designed for severing the roots at a short distance below the ground. The expense of this labor would not exceed the value of two cattle, and this number is much less than the average annual loss from the tall larkspur on this range. Similar conditions prevail on some of the mountain ranges in the vicinity of Deerlodge, Redlodge, and Bigtimber. On

[1] Pages 47, 64.

PURPLE LARKSPUR (DELPHINIUM BICOLOR).

the summit of the Big Belt Mountains, in the region of the Duck Creek Pass, and on both slopes for a considerable distance down from the summit, the tall larkspur grows so abundantly and over such wide areas that extermination by digging would seem to be quite impracticable.

In order to eradicate the plant when it is at its most dangerous stage it is necessary that stockmen familiarize themselves with the difference between it and the wild geranium in their earlier stages of growth.

SUMMARY.

The tall larkspur is a plant widely distributed in Montana, occurring, as a rule, in well-defined areas, especially on mountain ranges.

It has for several years been suspected of poisoning cattle, especially after snowstorms in spring and autumn.

Our observations show that the plant is sometimes eaten by cattle with fatal results. Extracts of the leaves of young plants when fed to rabbits produce alarming symptoms, and the same was true in one case when fed to sheep.

Experiments on cattle and one sheep indicated that permanganate of potash is an effective antidote when given in the first stages of poisoning.

Cattle should be kept away from patches of larkspur, especially during snowstorms.

PURPLE LARKSPUR.

(*Delphinium bicolor* Nutt.)

DESCRIPTION, HABITAT, AND DISTRIBUTION.

A smooth or somewhat pubescent, tuberous-rooted perennial, 1 to 2 feet high, with a cluster of finely divided long-stemmed root leaves and a varying number of rich purple flowers, which appear from May to August, according to altitude (Pls. IV and V). The flowers are usually few in number, but large, varying from 1 to 1½ inches in width. In Montana the plant is common throughout the State on moderately moist hillsides and mountain ranges at all elevations up to 10,500 feet. Its entire range extends from Colorado northwestward to Alaska. The typical form of the species is rather glabrate, but frequently grades into the variety *montanense* Rydberg, which is glandular-pilose throughout and has thicker leaves.

The purple larkspur is readily distinguished from the tall larkspur by its dark purple flowers and its smaller size. It blooms, moreover, about six weeks earlier, having been found during the season of 1900 in full bloom by the 1st of May. The distribution of the species is much more general and extensive in the State than that of the tall larkspur. During the season of 1900 it was observed on all of the

mountain ranges and in all the counties of the State which have been mentioned in giving the distribution of that species. The areas in which it grows are in some cases sharply defined, but, in general, they are not so definite as in the case of the latter species. In the greater number of places where it is abundant, it seems to be impossible to exterminate it by artificial means.

The purple larkspur is often found growing abundantly in the same situations with death camas, and in general its preferred habitat seems to be the same as that of this species. It does not, however, occur so abundantly as death camas in the shallow depressions and coulees of the plains. In fact, the purple larkspur is seldom found in situations far removed from foothills and mountains, though these localities seem to be the preferred place of growth for death camas. The soil in which it grows is generally compact and turfy, but it is frequently found in loose soil among shrubs and in scattering woods. The first green leaves begin to appear about the 1st of May or, in early seasons, the latter part of April, and the flowers bloom, according to altitude, anywhere between the early part of May and about the first week in June. The bright purple color of the flowers of this species serves to distinguish it at a considerable distance. Unfortunately, however, this plant is most frequently eaten before the flowering period, and it is, therefore, important for sheep herders to familiarize themselves with the appearance of the leaves, in order that they may be able to recognize the plant in any stage of growth.

HISTORY AS A POISONOUS PLANT.

Considerable difference of opinion as to the poisonous character of the purple larkspur exists between stockmen and other persons less financially interested in stock. The majority of the large holders consider it poisonous, while others, including men of scientific attainment, assert that stock can eat it, at least to some extent, with impunity. Experiments have been made which show that at one stage of growth the leaves of another species (*D. menziesii*) may be safely eaten, to a certain extent, by sheep. Dr. S. B. Nelson, professor of veterinary science in the Washington Agricultural College, in an article entitled Feeding Wild Plants to Sheep, published by the Bureau of Animal Industry of this Department, showed that it is possible to feed as much as $24\frac{3}{4}$ pounds of the fresh leaves of *D. menziesii* to a sheep within a period of five days without causing any apparent ill effect. The stage of growth of the larkspur was not stated, but, judging from the other experiments described in the same report, it was probably in a well-advanced flowering stage. Dr. Wilcox's experiments, published in the Montana Agricultural Experiment Station Bulletin, entitled Larkspur Poisoning of Sheep, show conclusively that the extract from less than an ounce of the dried leaves of the purple larkspur (*D.*

bicolor) was fatal to a yearling lamb, and the nature of the other evidence therein adduced is such that no room is left to doubt the toxic character of the plant, at least in its earlier stages of growth. In neither investigation were any experiments made to test the plant at more than one stage of growth. The following experiments were made with the view of ascertaining whether the permanganate of potash, which it was proposed to use in many cases of plant poisoning, could be used with satisfactory results as a chemical antidote in case of this plant, and also of determining which parts of the plant were most toxic. During some seasons the purple larkspur causes extensive poisoning of sheep and calves. Cattle and horses, on the other hand, seem to eat it less frequently than tall larkspur. In the season of 1900 conclusive evidence against this plant was obtained in only one locality. This was derived from two cases among calves in the Flathead Valley. The calves were about 5 weeks old, and at the time when the poisoning occurred, were running in a native pasture where the purple larkspur grew sparingly. The symptoms of poisoning in these two cases were similar to those already outlined from poisoning in the tall larkspur in cattle, with the exception that a slight bloating was to be observed in the case of the calves. The respiration and heart beat became exceedingly rapid as the symptoms of poisoning increased in severity. The body temperature was slightly lowered, and this was accompanied by profuse sweating. The increased perspiration may have been due in part to the violent spasms in which the animals finally died. Death occurred about four hours after the appearance of the first symptoms. No remedy was applied in these cases.

Post-mortem examination made on the two calves just mentioned as having died from larkspur poisoning disclosed the following conditions: No cerebral congestion was observed, nor had the larkspur produced any noticeable effect on the walls of the stomach. The blood was largely found in the venous side of the circulation. The veins in the mesenteries of the small intestines were much distended with blood. The same was true of the right auricle of the heart. The lungs were extremely heavy and full of blood, being in a condition similar to that which was found in post-mortems made on sheep which had been poisoned by death camas. In general the symptoms exhibited by these calves were closely similar to those which were observed during previous seasons in sheep which died from the same cause. The post-mortem findings indicated that the blood was insufficiently aerated, and the symptoms manifested by the animals just before death showed plainly that the respiratory centers were paralyzed and that respiration was for that reason shallow. When the respiratory movements are so rapid and shallow as they were observed to be in these cases the air is not renewed in the lungs, the breathing movements being merely sufficient to pump the air up and down in the trachea.

EXPERIMENTS.

The roots and leaves of nonflowering plants averaging about 3 inches in height, gathered May 26 at an altitude of about 8,000 feet on Bridger Peak, were kept moist and turgid in a tin botanical collecting box until May 28. Forty-two grams of the leaves was then ground in a sausage machine and soaked in 100 c. c. of distilled water at ordinary temperatures over night, heated a half hour at blood heat the next day, and then filtered by pressing through a linen bag until all the water was separated. Twenty-seven grams of the roots was treated with 50 c. c. in precisely the same manner at the same time. The resulting extracts were kept on ice over Decoration Day, while each of the residues was set to soak with 100 c. c. of 50 per cent alcohol. None of the extracts became moldy before they were used, their superior keeping quality over other similar extracts being in fact an argument in favor of their toxic character. Fig. 5 represents the stage of growth of the plants used in the first five experiments.

Experiment 1.—On June 1 10 c. c. of the water extract, equivalent to 4.2 grams of the fresh green leaves, was fed to a 17-ounce rabbit. The prominent effects noted after a couple of hours were a more rapid respiration and a dizzy motion of the head backward and forward.

Experiment 2.—On June 6 14 c. c. of the same solution, representing 5.8 grams of the leaf, was fed to the same rabbit. The same symptoms were displayed on the same day and the day following, but to a greater degree. On June 7 respiration was so labored that the whole body pulsated rhythmically to each movement. The heart action was also weak and very fluttering, and the animal refused to eat even when coaxed. The recovery was, however, complete.

Experiment 3.—The alcoholic extract obtained from the above 42 grams of leaves after extracting with water was evaporated to dryness over a water bath and the residue dissolved in 15 c. c. of about 30 per cent alcohol. Of this extract 1½ c. c., representing 4.2 grams of the fresh leaf, was injected hypodermically into a 40-ounce rabbit. The animal's respiration was greatly accelerated in three-quarters of an hour, but it had completely recovered by the next day.

Experiment 4.—On May 31 7 c. c. of the water extract of the root, representing 3¾ grams of the fresh material, was fed to a 63-ounce rabbit at 11.34 a. m. The animal was energetic and perfectly normal up to 12.40, when it was noticed that it appeared uneasy and that its breathing was irregular and rapid. At 3 o'clock, no additional symptoms having been noted, an amount of extract equivalent to 7½ grams of the fresh root was fed, and at 8 p. m. 10 grams more. The symptoms produced by the last two were not noted, but the effect was not fatal.

Experiment 5.—The alcoholic extract from the 27 grams of roots used in the last experiment was evaporated to dryness, the residue dis-

solved in 30 per cent alcohol as in experiment 3, and 1½ c. c., the equivalent of 2⅔ grams, injected hypodermically into a 55-ounce rabbit, but with no marked results.

In the next four experiments the extracts used were obtained by Mr. I. Cockrell from flowering plants which were rather badly wilted. The plants were divided into four parts—the roots, stems, leaves, and flowers—each of which was extracted over night with water at ordinary temperature and warmed a half hour at blood heat the next day. After this the extracts were filtered, and they were then ready for use. No extracts were made from this material with other solvents than water.

Experiment 6.—On June 1 15 c. c. of the root extract, representing 10 grams of the wilted plant, was fed to a 2-pound rabbit at 3.22 p. m. No effect having been noted, the dose was increased to 20 c. c. at 4.25. This was likewise without any marked effect, as was a third dose of 28 c. c., which was administered on June 6.

Experiment 7.—On June 1 15 c. c. of the stem extract, representing 5 grams of the wilted plant, was fed to a rabbit. Both the heart and the lungs were slightly stimulated, but in an attempt one hour later to administer a second dose the animal was accidentally killed.

Experiment 8.—On May 31 10 c. c. of the leaf extract, representing 6⅔ grams of the wilted leaves, was fed to a 26-ounce rabbit at 2.45 p. m. A slight uneasiness was noticed at 3.30, but otherwise the animal remained perfectly normal. Neither did any pronounced results follow a second feeding of 20 c. c. given at 8.5 p. m.

Experiment 9.—On May 31 10 c. c. of the flower extract, representing 3⅓ grams of the withered flowers, was fed to a 47-ounce rabbit at 11.27 a. m. At 11.55 there was considerable uneasiness, which was made evident by a shaking of the head and by holding the breath and then breathing rapidly. In addition to these symptoms drowsiness set in at about 12.43. At 2.05 there was a rhythmical movement of the head with each respiratory movement, which seemed to indicate that the brain was being affected. At 3.5 p. m. 30 c. c. more was given, but the only additional symptom noted was increased difficulty in breathing. At 8.5 30 c. c. more was given, but the symptoms were not noted. The effect was not fatal.

Summing up the results of these experiments, we find that the most prominent, easily observable symptoms were a stimulation of the respiration and a brain symptom manifested by dizziness or a rhythmical movement of the head. As it was not the object of the experiment to determine the symptoms of poisoning, these having been already secured by Dr. Wilcox, no special effort was made to determine the pulse rate, but it was to be noted that in experiment 2, which was as nearly fatal as any, the heart action was extremely rapid and weak.

None of the experiments proved fatal and no results were obtained on which a satisfactory trial of the permanganate of potassium as an

antidote could be based; hence no experiments were made in that line. Neither were the experiments numerous enough to deduce any positive results as to the comparative toxicity of the various parts. By inspection of the various experiments, however, it will at once be seen that the most satisfactory ones in this regard were the fourth and sixth, in which the water solution of extracts was fed. The equivalent of 44 grams of the root of the flowering plant was fed to a rather small rabbit, 26 ounces in weight, without causing any appreciable effect, while in experiment 4, where the roots from nonflowering plants were used, about half the quantity, 21¼ grams, produced some of the characteristic symptoms of the plant, although fed to a rabbit weighing 63 ounces—over twice as much as the other. It seems probable, therefore, that the older root is little, if at all, toxic. The fact that the alcoholic extract from 2⅓ grams of the young root was without effect on a 55-ounce rabbit when injected hypodermically is not significant. The experiments show that the root of the young plant is poisonous and tend to show that those of the mature plant are not. It is possible, however, that advanced age may alter the chemical combination of the alkaloid and render it insoluble in water without affecting its toxic character. Other more powerful solvents might have extracted the poison, but the limitations of time and the multiplicity of other experiments precluded further investigation.

The extracts for experiments 1, 2, and 8 were prepared in the same way. A comparison of the results is interesting, inasmuch as it tends to explain the apparently anomalous results referred to above, which were obtained when Dr. Nelson fed a very considerable amount of a related species of larkspur to sheep without noting any marked symptoms. The extract from 20 grams of leaves taken from partly wilted flowering plants produced only a slight uneasiness when fed to a 26-ounce rabbit, while very positive results were obtained in the other experiments where a much smaller amount of the extract was used. The weight of the rabbit in the latter case was somewhat less, but the difference was not at all sufficient to account for the difference in effect. That there is a positive difference is also evident from a few observations made on the comparative taste of the leaves at the two stages of growth. Those from young plants gathered at the same time as that from which Pl. V was taken had a decidedly bitter taste, and those from flowering plants gathered later were distinctly acid and rather agreeable. Our experiments show that there is a slight amount of poison in the leaves. Experiments 7 and 9 show that the stalks of flowering plants, and especially the flowers, are poisonous. It is very frequently asserted that the fatal effects of larkspur on stock are only produced when the root has been eaten. One of us, Dr. Wilcox, has, however, already shown that it is extremely difficult in most cases for animals to pull up the roots, and our experiments with the young

PURPLE LARKSPUR (DELPHINIUM BICOLOR), YOUNG PLANTS.

RED FALSE MALLOW (MALVASTRUM COCCINEUM).

leaves show conclusively that the eating of these in sufficient quantity is an adequate cause of death. The observation is of much value in emphasizing the necessity for herders to become thoroughly familiar with the larkspur in its earlier stages of growth. This is all the more important because the leaves, being succulent only when young, at which time they also constitute the earliest verdure in pasture land, are then especially tempting to stock. It is to facilitate the ready recognition of the young leaves that Pl. V is herewith supplied. Great care must be observed, however, in distinguishing the leaves from the earliest leaves of the red false mallow (*Malvastrum coccineum* Gray) (Pl. VI), a nonpoisonous plant which is extremely common in many pasture lands throughout the State. The showy red rose-like blossoms of the mallow, which appear from May to August, readily distinguish it from the larkspur, but before flowering the two plants may be easily mistaken on account of the close resemblance of the leaves. In both they are very finely divided, as shown in Pls. V and VI, but the mallow leaf is smaller and very much more densely covered with hair than the most hairy form of the purple larkspur. From the smooth form, which is most common, it may be distinguished at once, and an ordinary magnifying glass will easily disclose the peculiarly compound and radiating character of the mallow-leaf hairs.

SYMPTOMS OF POISONING.

The symptoms of poisoning from larkspur are, as before stated, generally to be distinguished from those of poisoning by death camas in its later stages. These two plants produce effects which at first are not very unlike. In cases of poisoning by either the first symptoms are almost invariably a stiffness and slight irregularity in gait. As the poisoning progresses regurgitation occurs in both, but is more pronounced in cases of poisoning from death camas than in those caused by larkspur. The final stages in cases of larkspur poisoning are accompanied by attacks of violent spasms interrupted by periods of rest. The last stages of death camas poisoning, on the other hand, are passed in a state of complete muscular paralysis.

Attention has already been called to arbitrary variations in the appetite of domesticated animals. This fact is illustrated under range conditions by the changes in the choice of food plants by stock in different years. During two previous seasons quite conclusive evidence was obtained that large numbers of sheep were poisoned from eating the purple larkspur. During the summer of 1900, however, no sheep were seen eating the plant, and no evidence was obtained to show that it had been eaten. On one range a band of sheep were driven over an area of purple larkspur twice each day in going in and out of the corral. A close examination of this field of larkspur failed to disclose a single specimen which had been eaten by the sheep.

During the spring, however, this whole band of sheep was poisoned from eating death camas. Observations in the field indicate that the purple larkspur is not as virulent as death camas. When, in addition to this, it is considered that death camas is apparently eaten more frequently than the purple larkspur, it would seem to be a safe assertion that death camas is the most important plant concerned in cases of spring poisoning of stock.

REMEDIAL AND PREVENTIVE MEASURES.

In cases of poisoning from this plant the same remedies should be applied which were recommended for poisoning by the tall larkspur.

As most of the cases of poisoning occur before larkspur is in bloom, it is important that stockmen should make themselves familiar with its appearance in the earlier stages of growth, in order to be able to herd sheep away from it at that period.

SUMMARY.

The purple larkspur is a plant which is widely distributed in Montana, especially on foothills and mountains, where its deep blue flowers are conspicuous over wide areas in springtime.

For a number of years it has been considered fatal to sheep and occasionally to other stock, and this view has been confirmed by our investigations.

Sheep are more often poisoned by purple larkspur than are other domestic animals.

Our observations during the past few years have shown a striking variation in the appetite of sheep with reference to this plant.

Our experiments indicate that both the leaves and roots of young plants are poisonous and that the plant is most dangerous during the early stages of growth before flowering.

The previous experience of one of us had shown that atropine is the best antidote for counteracting the physiological effect of this plant. Permanganate of potash and sulphate of aluminum should be administered as a chemical antidote.

WYOMING WATER HEMLOCK.

(*Cicuta occidentalis* Greene.)

Other names: Water hemlock, cowbane, spotted cowbane, wild parsnip, etc.

DESCRIPTION, HABITAT, AND DISTRIBUTION.

A smooth perennial 2 to 5 feet in height, with 3 to 10 fleshy, tapering roots, 3 to 5 inches long, clustered at the base of the ascending axis; leaves doubly compound, with narrow serrate leaflets 2 to 3 inches in length; flowers in clusters, dull greenish-white (Pls. VII and

WYOMING WATER HEMLOCK (CICUTA OCCIDENTALIS).

WYOMING WATER HEMLOCK (CICUTA OCCIDENTALIS), YOUNG PLANT.

VIII). The plant differs from the common eastern water hemlock in the more elongated spindling roots and the duller color of its flowers. One striking peculiarity of the root is its characteristic musky odor, which is observed especially when a small quantity of the juice gets upon the fingers. It is generally distributed through the State. Outside of Montana it is found abundantly in Wyoming and Colorado, and in less quantity from the Rocky Mountains of Colorado to the Sierra Nevada of California and northward.

In Montana the Wyoming water hemlock was observed in every county. Its ordinary habitat is along the banks of streams and irrigation ditches, on wet railroad embankments, and in swamps and wild meadows. In general it was noticed that in portions of the State west of the Rocky Mountains this plant was more abundant in wild meadows, which are cut for hay, than was the case in the eastern part of the State. In Flathead, Missoula, Deerlodge, and Granite counties it grows rather abundantly in many such meadows. In the eastern part of the State, however, as just indicated, the distribution of the plant is almost strictly confined to the banks of streams and irrigation ditches of long standing.

HISTORY AS A POISONOUS PLANT.

In Montana this plant is most commonly known by the name "wild parsnip," and it appears that from the use of this name, a mistaken notion has arisen that this is identical with the common parsnip of the garden. A number of cases of poisoning have happened in Montana from eating this species, and since the term wild parsnip is commonly used to designate the cause, it has come to be believed by a large number of persons that the garden parsnip, when allowed to escape from cultivation and run wild, acquires poisonous properties. The two plants should be readily distinguished. The flowers of the garden parsnip are yellow, while those of the water hemlock are white. The latter is a much slenderer and a much less leafy plant than the former, and the leaves of the water hemlock, while of the same general shape, have much finer subdivisions. Not only water hemlock, but a number of other plants belonging to the parsnip family are often called by the name of wild parsnip, as if they all belonged to the same species. Among the plants whose identity is thus mistaken may be mentioned the cow parsnip (*Heracleum lanatum*) and species of Lomatium, Phellopterus, and Leptotaenia.

The number of cattle poisoned by water hemlock in Montana during 1900, so far as conclusive evidence could be obtained, was 36, and of these 30 died. About 105 sheep were poisoned by it the same year, 80 of which died. The percentage of fatal cases, therefore, is very large, being 76 per cent with sheep, and 83 per cent with cattle. The roots of this plant are occasionally eaten by man, usually with fatal

results. During the season of 1900 in Montana there were five cases of poisoning in human beings from this cause and four deaths. This species seems to be equally as dangerous as the better known water hemlock (*C. maculata*) of the Eastern States. The symptoms described are practically identical with those produced by the eastern plant. Full observations on water hemlock were confined to determining the extent of its distribution, and the frequency with which it is eaten by different animals. The time of year when it is most frequently eaten by sheep and cattle is that of its active growth when it offers an abundance of tempting fodder, mainly before the flowering stems are produced. During the season of 1900 the water hemlock began to bloom over the greater part of the State about June 15.

This plant, as already stated, grows in rather wet places, and, except where grasses have formed a tough sod, its roots may be readily pulled up with the stem. In fact this is what usually happens, since the stem is firmly united with the roots and is not easily broken at their junction. It was not determined to what extent the roots are eaten by sheep and cattle when pulled up in connection with the stem. In a number of cases of sheep poisoning the roots had been eaten and were found in the stomach of the victims. In other cases an examination of the locality where the poisoning had occurred showed that the plants had been pulled with the roots attached, but the latter had been left lying upon the ground. In still other cases water hemlock had been eaten off without disturbing the roots. Field observations indicate that the leaves and stems, including the basal portion of this plant, at least during the early stages of growth, contained sufficient poison to produce death. The roots contain a virulent poison. In the cases of human poisoning the only portion of the plant eaten was the roots. Mr. E. J. Moore, of the Agricultural College, informed us that his father lost horses occasionally while plowing up new land bordering on marshes, the horses in these instances eating the roots. A few cases of the poisoning of horses from eating meadow hay containing the plant have been reported to this Department from Montana. Some farmers are of the opinion that the tops of the young plants, exclusive of the roots, are poisonous when less than a foot or so in height, and that later the whole top may be eaten with impunity. Instances of stock eating the tops in the more advanced stages without injury were cited by at least two persons.

EXPERIMENTS.

Experiment 1.—The upper portion of nonflowering plants less than a foot in height were gathered June 3, and having been kept turgid in a tin box, were fed June 4 and June 5. In the first case the material was fed out of hand in small pieces to a 1-pound rabbit until, after ten minutes, it had eaten all of sixteen leaves. The remainder of 60 grams

was then placed in the cage, and after forty-five minutes 12½ grams in all had been eaten. The rabbit ate the first portion quite readily, but it had practically refused to eat more of the Cicuta, even when coaxed, at the end of a half hour. It was then decidedly uneasy, and its respiration was unusually rapid. Ten minutes later it had voided a considerable amount of urine, which relieved it from most of its symptoms, but five minutes later still its temperature was 102.4°, that of a check being 100.8° F. A little irregularity of breathing was noted three and one-half hours after the beginning of the experiment, but the next day the rabbit seemed perfectly normal.

Experiment 2.—In the preceding experiment all of the aerial portion of the plant was used. In this the thick, whitish basal portions of the leaves, which were thought to be more poisonous on account of their more oily appearance and their pungent taste, were discarded. Fifty grams were offered to a 1-pound rabbit. The amount which had been eaten five hours afterwards was 12 grams or more, as was ascertained by weighing the uneaten part and making proper allowance for the evaporation of water, which was determined by weighing a check amount of equal weight that had been exposed to practically the same conditions. No effect whatever was produced.

Experiment 3.—On June 9 50 grams of the fresh tops of the non-flowering plants (1 to 1½ feet high), exclusive of the white basal portions, was eaten by a rabbit weighing about 1½ pounds without causing any marked symptoms.

These experiments do not afford sufficient data upon which to base any very definite conclusions, but it seems certain that the basal portion of the leaves of young plants is more toxic than the green foliaceous part, and it may be safely assumed that the leaves of the older plants are likewise less toxic. When the stems are older, they are not so tempting to stock in Montana, because at that time there is an abundance of wholesome fodder, and it may be that the mere failure of stock to eat the stems in that stage has given rise to the idea that the tops of the older plants are not poisonous. It is more than likely that the older stems, containing as much oil as they do, are poisonous, but to a much less degree than the root, which is responsible for a large percentage of the cases of water-hemlock poisoning which occur in the State.

Experiment 4.—The remedies which were tried in cases of poisoning by this plant include morphine and chloral hydrate, combined in a few instances with emptying the stomach by means of rumenotomy (paunching), and the use of cathartics. Potassium permanganate was not tried in any of these cases for the reason that the violent physiological effects of the poison were already sharply pronounced when the animals were seen. It was thereby evident that most of the poison

had already been absorbed out of the stomach, and could therefore not be affected by permanganate of potassium in the stomach.

Two sheep were given morphine hypodermically in quarter-grain doses at intervals of five minutes. No decided effects of the morphine were observed until after the third dose, when the sheep became gradually calmer. After receiving five doses both sheep lay down in a partly stupefied condition, from which they did not arouse for several hours. These sheep ultimately recovered from the poisoning, although its effects were noticeable for four or five days.

Experiment 5.—An experiment was tried with chloral hydrate as an antidote for poisoning by water hemlock. One sheep was given one-half ounce of chloral hydrate in three equal doses at intervals of ten minutes. The effect of this substance was not so immediate as was that of morphine, but seemed to be otherwise very similar. The sheep finally passed into a stupor similar to that produced by morphine, from which it emerged after about two hours. The sheep did not manifest any further violent symptoms as the result of the poisoning, but it did not recover its appetite, and, after drooping about for three days, finally died. It would seem that in this case the violent effects of the poison were not counteracted quickly enough to enable the animal to make a final recovery.

Experiment 6.—In one case where four cows were poisoned with water hemlock one of the number was seen when the first symptoms of poisoning began to be shown. The stomach was at once opened at the point where the ordinary operation of paunching is performed and the stomach contents were removed. A large enema of lukewarm water was then given, followed by a drench of melted lard. No direct antidotes were given in this case. The animal, however, did not exhibit the most violent symptoms of the poisoning and made a complete recovery after two days without any further care. The three other cows died before any treatment could be given. In one other case of poisoning from water hemlock a cow was given two 1-ounce doses of chloral hydrate fifteen minutes apart with very satisfactory results.

SYMPTOMS OF POISONING.

The symptoms of poisoning from this plant were most closely studied in sheep. The animals manifested signs of severe pain very quickly after the appearance of the first symptoms. In sheep the first sign of poisoning was usually an attempt on the part of the sheep to run away from the band or to run in any direction in which it happened to get started. There were also manifestations of great cerebral frenzy, accompanied by involuntary muscular movements which resembled to some extent the movements of animals when suffering from colic. The respiration was labored and somewhat irregular, the pulse was wiry and intermittent. It is, however, a difficult matter in most cases

to make reliable observations on this point, for the reason that an attempt to manipulate the animal always results in increasing the mental excitement and the violence of the muscular spasms. These spasms rapidly become more and more severe as the cerebral excitement increases until the animal appears to be in an unconscious condition and dies in the most violent spasms. In some cases of cattle poisoned by this plant the victims died within fifteen minutes after the first signs of poisoning had appeared. In other cases among both sheep and cattle where the first symptoms succeeded one another less rapidly the animal lived for two or three hours, dying finally from exhaustion, apparently as the result of the violent muscular convulsions.

REMEDIAL AND PREVENTIVE MEASURES.

Water hemlock is to be considered as a dangerous poisonous plant, especially because so large a percentage of the animals poisoned by it ultimately die, and because its action is so rapid that the possibility of treating a large number of simultaneous cases is practically precluded. It will readily be understood that in any case where several hundred animals are poisoned at the same time considerable skill will be required to administer even a simple treatment to each animal in time to prevent the fatal effects of the poisoning. But the difficulty is especially great when one has to deal with a plant like water hemlock, of which a fatal dose may produce death within fifteen minutes. As already indicated, antidotes for poisoning from this plant may be applied with success if the animals are noticed immediately after the first symptoms of poisoning appear. Too often, however, especially in the case of cattle, the poisoning is not discovered until it is too late to give any remedial treatment.

Permanganate of potash should be promptly administered as previously recommended for poisoning by other plants. If violent symptoms are already apparent, give morphine or some other sedative hypodermically. In no case should these be administered by way of the mouth if the permanganate has already been given. Morphine should be given in doses as follows: For adult sheep, 1½ grains; for cattle and horses, 3 to 10 grains.

The distribution of water hemlock is much less extensive in the localities where it grows than is that of death camas. It would seem, therefore, to be a comparatively easy matter to prevent sheep from grazing on areas where it occurs, at least during the spring and summer. It seldom happens that water hemlock is found along the whole course of the stream or around the whole circumference of a lake. There are, in nearly every case, places free from it at which the sheep could be watered with safety. In case the water hemlock grows along the banks of the stream at points which are the most convenient watering places, it could here be exterminated with a moderate

amount of labor. This can be done by repeatedly cutting it down, or in other ways. It is advisable to avoid the use of hay containing water hemlock. The plants should be removed from native meadows before mowing. Sheep herders should become thoroughly acquainted with the appearance of the plant, so as to be able to recognize it in any of its stages. An illustration of the value of such knowledge is found in the case of a herder who made several attempts to water his sheep at different points along the bank of a certain stream with disastrous consequences in each case. A close observation would have shown that the same plant was the cause of the poisoning in all cases.

SUMMARY.

Water hemlock is widely distributed in Montana along water courses and in swampy places from the lowest altitudes up to about 7,500 feet.

The roots have long been known to be fatal when eaten by stock, and cases of poisoning of stock have been reported from eating dry seeded specimens in hay.

Our observations from May to July, 1900, showed that a number of cattle and sheep ate the young plants, including in some cases the roots, with fatal results in about 80 per cent of the cases.

Our experiments demonstrated that the basal portions of the plants less than 1½ feet high were poisonous to rabbits, and that morphine and chloral hydrate are useful in counteracting the physiological effects of this plant.

In cases where large quantities of the plant, especially the root, are eaten, death results so quickly that remedial measures can not be applied.

WHITE LOCO WEED.[1]

(*Aragallus spicatus* (Hook.) Rydberg.)

DESCRIPTION, HABITAT, AND DISTRIBUTION.

An erect, tufted perennial, 4 to 18 inches high, without branches, with pinnate leaves and narrow leaflets and spikes of white or slightly cream-colored flowers resembling those of the pea (Pls. IX and X). The pod is one-celled and when ripe the seed produces a rattling sound which gives the plant the name rattleweed. It is exceedingly common throughout the State, but grows most abundantly on the northern slopes of foothills and mountains up to an altitude of about 8,000 feet. While it grows freely on nearly all the important ranges of the State, it is most abundant in Judith Basin, the Musselshell country, and the Yellowstone Valley. The situations in which it grows are for the most part rather dry, and in many cases it is found quite abundantly on dry prairie ranges. The habitat of the plant seems

[1] For other loco weeds, see page 99.

WHITE LOCO WEED (ARAGALLUS SPICATUS), IN FLOWER.

WHITE LOCO WEED (ARAGALLUS SPICATUS), IN FRUIT.

to vary slightly in different parts of the State. In the Judith Basin and in the Sun River country it does not grow plentifully on the level prairie, while in these same regions the foothills are so completely covered with it that they appear as large white tracts when the plant is in full bloom. On the other hand in the range country along the course of the Musselshell River the white loco weed is met with more extensively on the high prairie ranges. Attention has already been called to the fact that as a general rule native ranges are freer from poisonous plants the farther one goes away from the mountains. This statement is also true of the white loco weed, which seldom occurs abundantly on any prairie range in Montana at a distance of 20 miles from the mountains.

HISTORY AS A POISONOUS PLANT.

For many years a disease called loco, affecting cattle, horses, and sheep, has been generally known to the stockmen of the western ranges. This disease has most commonly been attributed to the action of certain plants, more rarely to that of alkali. Several species of plants have been suspected of producing the loco condition in animals and have been called loco plants or loco weeds and also crazy weeds from the nature of the disease. Nearly all of the plants which have been considered loco weeds belong to two genera of the pea family, Astragalus and Aragallus. These genera are represented by numerous species on the western stock ranges. Most of the species are somewhat restricted in their distribution either to the southern or northern portion of the range country, or grow more abundantly in one region than in another. In Colorado the plant which is most commonly known as loco weed is *Astragalus mollissimus.* In Montana, on the other hand, the plants most generally called loco weeds by the stockmen are species of Aragallus. A number of other plants have occasionally been mistaken for loco weeds, and among these may be mentioned species of Astragalus and lupine. The species which is most concerned in causing the loco disease in Montana is *Aragallus spicatus* and is closely related to *A. lambertii.*

It is the belief of a number of stockmen that a condition almost, if not quite, the same as the loco disease may be produced in sheep by eating undue quantities of alkali soil. Reference has already been made to the fact that some stockmen do not salt their animals at all, or only at long intervals. When animals are not salted regularly they soon discover localities where large quantites of alkali are found in the soil and visit such places frequently for the purpose of eating this alkali soil. A few of the more observant sheep raisers have come to believe that sheep are less apt to become locoed when regularly salted than when they eat large quantities of alkali in consequence of not being supplied with salt. For this fact two explanations have been offered.

On the one hand a number of sheep raisers believe that the eating of large quantities of alkali is itself the cause of the loco disease. A few sheep men have maintained that the locoed condition is in every case due to eating alkali or to drinking strongly alkaline water. This assertion is definitely disproved by the fact that sheep and horses are known to have become locoed while feeding on mountain ranges where no alkali soil was to be found and where all of the water was free from alkali. A considerable number of sheep became locoed while feeding on a range of this character on the slopes of the Rockies near Augusta, Mont. No alkali was to be found on this range in either soil or water. These sheep were removed to another range where the loco weed did not grow so abundantly, but where all the water was somewhat alkaline. Their condition improved slightly under the changed conditions, although they were still able to find and eat the loco weed in small quantities.

On the other hand, an equally large number of sheep men believe that there is no connection between the loco disease and alkali. A second explanation for the observed fact that sheep most frequently acquire the loco habit when not salted is that the lack of salt and the physiological action of the alkali may bring about a depraved appetite which manifests itself in the formation of the loco habit. As already stated in a previous part of this report,[1] the different forms of alkali, such as are found in Montana, can scarcely be considered substitutes for common salt in the animal economy. Disturbances in the normal physiology of animals are likely to result in the majority of cases from total absence of salt. It is well known that a number of diseased conditions in animals are accompanied with manifestations of a depraved appetite. From a general description given of the loco disease it is apparent that this condition might very justly be termed a perverted appetite. It has, to be sure, not been demonstrated by actual observation that the depraved appetite which is shown in the formation of the habit of eating loco weeds is in every instance the result of the first taste of these plants. A number of observations made by the principal sheep raisers and by ourselves indicate, as already stated, that sheep more frequently form the habit of eating the loco plants when not regularly supplied with salt than when abundantly furnished with this substance. All reliable observations point to the conclusion that it is highly desirable to supply sheep with a sufficient quantity of salt, which they can get whenever they wish it.

It has been frequently suggested that the peculiar effects produced by eating loco weeds are due to inadequate nutrition. In such a theory it is of course assumed that the loco weeds do not contain the elements necessary to the diet of a sheep or horse. The proof of this assertion is not forthcoming, and it seems more reasonable to believe that the

[1] Pages 20, 21.

plants contain a poisonous principle which is harmful to domestic animals.

It should be stated also that the larvae of sheep bot flies, which are frequently found in the frontal sinuses of the head, can not possibly be considered the cause of the nervous symptoms characteristic of the loco disease, for the reason that these larvae are not found in greater abundance in locoed than in healthy sheep. For the same reason the presence of the common tape worm (*Taenia serrata*) in the small intestines and bile duct of sheep can not be considered as the cause of the locoed condition. These worms are almost universally present in the intestines of sheep, and under ordinary conditions do not cause any recognizable disturbances. The disease of sheep known as gid is not to be mistaken for the loco disease and, furthermore, is not prevalent in this country. No indications were found during the post-mortem examinations that the walls of the stomach were affected to any appreciable extent by the action of loco weeds, although these plants were invariably found in the stomach contents of such sheep. In the majority of cases no apparent changes have been produced in the spleen, liver, or kidneys. In some instances a slight congestion of the intestines was noticed. The cerebral membranes were in all cases somewhat congested. This condition is probably one of the immediate physical causes of the mental excitement exhibited by locoed animals. Post-mortem examinations of locoed horses disclosed the same conditions as those found in the sheep.

The most reliable observations on the subject of loco disease indicate that it is the result of eating undue quantities of certain weeds, of which a number are known. The disease may assume either an active or chronic form. In the active form the animal lives but a few days, while in the chronic form it may live for two or more years and manifest the same symptoms in a milder degree. The eating of alkali may bring about a perverted appetite which leads the animal to eat loco weed. Otherwise alkali seems to have no connection with the loco disease.

The horse and the sheep are the animals which are most frequently affected by loco disease. Cattle occasionally acquire the loco habit, but the cases are comparatively rare. In certain parts of Montana the habit became so wide-spread among horses that the raising of them was abandoned until the locoed animals were disposed of and other horses which had not the loco habit had been imported.

That this plant is seldom eaten by sheep, even under stress of hunger (unless addicted to its use), is evident from the fact that in a case of poisoning which happened near Toston, Mont., everything else, including the terminal branchlets of greasewood (*Chrysothamnus nauseosus*) and sage brush (*Artemisia tridentata*), and even the thorny branches of a wild rose, was eaten, while many flowering plants of the white

loco weed were left uneaten. No evidence was, in fact, obtained to show that any of the plants had been even slightly browsed upon by the sheep.

During the progress of field work in Montana in 1900, about 650 locoed sheep and 150 locoed horses were seen. The locoed horses were nearly all in one herd, and of the 650 locoed sheep 500 were in one band and 150 in another. The owner of the band in which 500 locoed sheep were found had lost during the preceding winter 700 sheep from loco weed. The extent of losses among stock from eating loco weeds is probably larger than is usually suspected. The appearance of locoed animals has become so common that it attracts little attention, and few reports are made by individual stockmen on the number of animals affected by loco disease. Among sheep the number could be ascertained with comparative ease, but with horses an estimate of the number could only be made after a careful round-up. It is safe to assume that the number of the latter is large, since a few are to be seen in almost all parts of the State.

EXPERIMENTS.

The specimens used in experiments 1 and 2 were collected May 25, by Arthur Williams, on gravelly plains near Crow Creek, at Toston, Mont., and were received May 27. They were kept moist in a tin box until May 28. The plants were mostly in fruit, but some specimens were still in flower, and when used all parts were turgid as they are when fresh. The larger semi-fleshy and coriaceous pods were separated in one lot, while the leaves were put in another. The large fruiting specimen and the small showy flowers shown in Pl. X illustrate the stage of growth of the parts used in experiments 1 and 2. Both parts were extracted with water and 50 per cent alcohol in the same way.

Fifty grams of the leaves and the flowering top (no large pods) were thoroughly rubbed up in a mortar with about 90 c. c. of water and allowed to soak over night at ordinary temperature. It was then warmed over a water bath at about blood heat for a half hour, after which the water extract was separated from the fiber by means of a filter pump and by squeezing tightly in a strong linen bag. The residue was set to soak with about 90 c. c. of 50 per cent alcohol, while the filtrate, to prevent contamination by molds, was placed on ice and kept cold until May 31. Both the alcoholic and water extracts were finally made up to 100 c. c. in volume.

Experiment 1.—On May 3, at 11.10 a. m., a young Belgian hare weighing 32 ounces received in the stomach by means of a syringe 10 c. c. of the water extract. A slight uneasiness was apparent at 12.45, and a noticeable lack of appetite at 1.35, when five other rabbits, dosed with other extract at the same time, were eating well. At 2.50, 15 c. c.

more was given in the same way. The uneasiness continued, and at 3.25 the animal was quite drowsy, a symptom which continued until 3.50. At 4.5 its appetite was better. Twenty cubic centimeters were given at 7.45, shortly before stopping work for the day, but no symptoms other than a slight drowsiness were noted. The stock solution was slightly moldy on June 5. On June 7 the rabbit's respiration was rapid, and the animal was bright and vigorous. None of the commonly described symptoms of loco weed poisoning were noted at any stage of the experiment, but it is quite possible that had the feeding of the extract been continued they would have developed. The experiment simply indicates that the water extract of the leaves, as prepared in the above way, is not an acute poison in the doses administered.

The residues, after extracting the pods and the leaves respectively with water on May 28, were soaked in 50 per cent alcohol until June 16, when they were filtered and given hypodermically to two rabbits. One and a half cubic centimeters of the leaf extract, diluted so that it contained but 33 per cent of alcohol, produced no noticeable effect other than that produced by the alcohol itself. The same amount of the 50 per cent alcoholic extract of the pods was likewise without noticeable effect.

Experiment 2.—On June 13 more of the plant, with fully developed green pods, was secured and, exclusive of the tough stems, was ground up in a sausage machine and extracted for an hour at ordinary temperatures by grinding up small portions in a mortar with an equal weight of water. All of the fractional parts were placed together and the extract separated by means of a filter press. This was slightly diluted, so that a cubic centimeter of the liquid was equivalent to a gram of the fresh material. On June 14, 250 c. c. of this was fed at 8.30 a. m. to a sheep weighing about 60 pounds. No effect having been noted, an equal amount was administered in the same way at 11 o'clock. No toxic or even prominent physiological effect was noted the next morning, when the animal grazed as usual.

Experiment 3.—An acute case of loco disease was observed in a two-year-old ewe with a lamb at her side. The band had been moved to a new part of the range on the morning of May 22, and the ewe in question was observed eating large quantities of the white loco weed (*Aragallus spicatus*). She was first seen eating this plant at 10 o'clock a. m., and about 7.30 p. m., when the herder started the band for the corral, she was unmanageable and the lamb was sick. An examination of the ewe at this time showed that she was completely blind. A slight locomotor ataxia was manifested. The ewe walked around in long circles to the right, the neck being curved in that direction. Whenever she came in contact with any object, she pushed against it until exhausted and then remained standing for an instant in a sort of stupor. At the beginning of each attack the head was slightly elevated

and turned to the right. The eyelids twitched rapidly and there was a slight champing of the jaws. After this manifestation the animal began to walk in a circle to the right. Each attack lasted from one to two minutes and the intervals between the attacks were about five minutes. On the morning of the second day it was at once apparent that the attacks were becoming more severe. Their length and the interval between them were the same as on the previous day. The head was now turned much more decidedly to the right and the animal walked around in much smaller circles. The lips and eyelids twitched violently and the jaws were moved upon one another with such force that the sound could be heard for a distance of 200 yards. Similar symptoms, accompanied by digestive disturbances, were manifested in the lamb during the second day, and it died in the afternoon. On the morning of the third day it was found that the ewe had apparently been pushing against the fence during a greater portion of the night and was in a much more serious condition than on the second day. She now wheeled around and around to the right, the neck being curved so abruptly as to cause her to fall frequently. It was noticeable, however, that the involuntary twitching of the eyelids and lips and the grinding of the jaws had ceased. The spasmodic muscular movements were largely confined to the legs. By the afternoon of the third day the animal was unable to stand and the symptoms were entirely confined to convulsive movements of the legs. On the morning of the fourth day the animal died. The pupil of the eye was at no time dilated and its expression was perfectly normal. The pulse on the first day was irregular and intermittent. From 8 to 10 beats occurred in rapid succession, followed by an interval in which from 4 to 5 beats were omitted. On the second day the pulse was regular and of normal frequency and strength. During the third day the pulse became rapid and weaker. The respiration was at first perfectly normal, during the second day it became more rapid, and on the third day it was exceedingly shallow and rapid. The only remedy which was tried in this case consisted of frequent hypodermic injections of one-fourth-grain doses of morphine. During the forenoon of the second day six doses were given at intervals of fifteen minutes, apparently with no effect. The attacks of trembling and spasms became during this treatment more severe, as they probably would have done if no morphine had been administered. In the lamb belonging to this ewe potassium permanganate was tried. One dose of 1 gram of this substance was given by means of a direct injection into the stomach. The lamb lived much longer than other lambs which were affected in the same way and were not treated, but it finally succumbed. Two other ewes ate small quantities of the loco weed at the same time and were affected in the way which has just been described, except that all of the symptoms were mild in degree. In these two cases morphine

was again tried with much better success. The spasms became less pronounced and the ewes recovered on the second day. The lambs, however, had died in the meantime from the poison contained in the milk of the mother. The lambs in these three cases were two weeks old and had not eaten loco weed or any other plants.

SYMPTOMS OF POISONING.

The symptoms of loco disease in animals are familiar to all stock raisers. Perhaps the most characteristic are those of cerebral origin, consisting in peculiar irregularities in gait and action, which may be compared to a drunken condition in men. Sheep and other animals affected by this disease are commonly said to be crazy or locoed. The cerebral disturbance may consist in an impairment of the function of the special senses, or in improperly regulated motor impulses which produce a more or less pronounced incoordination of muscular movement. Sight is frequently much impaired. In some cases the animal soon becomes totally blind. This condition is reached more often in acute cases than in chronic cases of loco disease. More frequently the animal simply sees incorrectly or makes errors in judgment of size or distance of objects. These errors in judgment of ocular perceptions are a common occurrence and are often so pronounced as to become ludicrous. A locoed horse upon being driven up to a gate may either attempt to jump over the crossbar, which is usually placed at the height of about 15 feet, or may lower his head from fear of striking it. Simple experiments indicate that both sheep and horses in a locoed condition frequently mistake harmless things for dangerous enemies. In horses which are affected with the chronic form of loco disease one has abundant opportunity to observe many peculiar and senseless actions which are evidently due to cerebral disease. Locoed horses are often used for both draft and driving purposes. Such horses may work or travel in a perfectly normal manner for days at a time. They frequently, however, run away or are attacked with kicking fits without any apparent external cause. Observations made on horses which are only slightly locoed indicate that they do at times become frightened by purely imaginary objects. This fright would seem, however, to be none the less real, since such horses often tremble or become covered with a cold sweat after these imaginary dangers are passed.

The sense of hearing is frequently affected in locoed animals, as is easily demonstrated by simple experiments. The response to various sounds and noises is not always in accordance with the character or volume of the sound. At times a loud noise is unheeded, while at other times a slight noise of the same character may produce fright. The locoed animals are often unable to judge correctly the direction from which sounds come.

Irregularities of the muscular movements of locoed animals may

assume a variety of forms. The animal may simply carry its head in an extended or otherwise unnatural position. In some cases the arched carriage of the back is to be noticed with awkward movements of the legs. Trembling is a frequently noticed characteristic of the locoed animal. This may be confined to the legs, especially to the knees, or may involve all the voluntary muscles, and occurs in a most pronounced manner after any fright which the animal may have experienced. It is often observed of locoed horses that even when they are able to move forward with considerable precision they experience difficulty in backing.

It is the universal experience of sheep raisers that locoed sheep are exceedingly difficult to herd. The sheep may, without a moment's warning, stray away from the band, each one in a different direction, and it is easy to understand how nearly impossible it is to prevent such a band of sheep from becoming separated. Besides giving the herder much trouble in directing the course of the band on the range, locoed sheep often refuse to enter the corral at night, and under any and all circumstances may suddenly manifest perplexing stubbornness.

Few cases of locoed cattle have come under our observation. The symptoms, however, in cattle are essentially the same as in sheep and horses. Occasionally locoed cattle manifest dangerous symptoms and attack man or animals. It is difficult to understand why the loco habit is apparently so rare in cattle as compared with sheep and horses. In their ordinary feeding habits cattle can hardly be said to be as fastidious in selecting forage plants as horses. The fact remains, however, that cattle do not acquire the habit of eating loco weeds to any great extent.

Many sheep raisers believe that in sheep one of the effects of eating the loco weeds is an elongation and loosening of the teeth. As this condition is almost invariably noticed in sheep from a year and a half to two years old it would appear to be quite possible that this is merely the natural phenomenon of shedding the teeth, which occurs at the age just mentioned. The symptom in question is one which is almost always mentioned by sheep raisers as characteristic of the locoed condition. No careful and continued observations have been made which would enable one to come to any definite conclusion in regard to the matter. The suggestion that the loosening of the teeth is merely a natural process of shedding the teeth was made by Dr. M. E. Knowles, State veterinarian of Montana, and seems, according to available observations on the subject, far more reasonable than the other theory. As this loosening of the teeth occurs at the age when the loco habit is most apt to be acquired, in the frequent examinations made by stockmen it might easily be mistaken for an effect of eating loco weed.

In chronic cases of the loco habit in sheep the animal, as already

stated, becomes more and more emaciated and crazy. One of the frequent effects of this habit is the shedding of the fleece as a whole or in patches. The animal becomes unable to take care of itself and, unless carefully watched, is apt to fall into the water and be drowned while attempting to drink. The sight becomes more and more affected until the animal is unable to direct its course properly or to keep along with the band. Fits of trembling are of frequent occurrence during the later stages of the disease, and finally the animal dies from inadequate nutrition and total exhaustion as the result of the muscular convulsions.

In chronic cases of loco disease in horses the animal is usually left to its own resources on the range. During the later stages it loses to a large degree the power of locomotion and remains for two or three weeks at a time upon a small area of ground. We have had the opportunity of observing a number of such cases in horses which were almost unable to walk. Under these circumstances the animals seldom or never lie down, and it may be doubted whether they could get up if they once should lie down. One horse which was under continuous observation for a period of two weeks in 1897 remained during this time upon a piece of ground about 150 feet square. The ground and vegetation were unusually dry, and the horse had no water during the two weeks. At the end of this time the animal walked about 1 mile to a small stream where, in attempting to drink, it fell and was unable to get upon its feet again. It seems very difficult to understand how, under the dry conditions of the open plain, animals can live so long without water.

Numerous autopsies made on locoed sheep and horses revealed conditions which, though fairly uniform, did not constitute a well-defined series. Naturally the post-mortem findings in case of animals allowed to die a natural death from the loco disease will differ from those of animals which are killed and bled before being examined. As stated in the description of the symptoms, locoed animals usually die in more or less violent spasms. As a result of these spasms the blood is found after death unevenly distributed in the blood vessels. The lungs are frequently found to be congested for the reason that the blood was inadequately aerated at the time of death. We made a large number of post-mortem examinations upon bodies of locoed sheep which had been killed and bled immediately before examination. In these cases there was no lesion or marked changes in the alimentary tract. A slight congestion of the membranes of the brain was to be observed in all cases. The lungs and heart were apparently not affected. The voluntary muscles were of a paler color than under normal conditions, and the fat tissue was considerably reduced in quantity.

Undoubtedly a serious mistake has been made by a majority of sheep men who have suffered losses from the loco disease in allowing the

locoed sheep to remain with the band. The loco habit seems to be learned by imitation, and as long as locoed sheep are allowed to remain with other sheep the number of cases of locoed animals rapidly increases. Stockmen have frequently suggested the possibility of animals inheriting the tendency to eat loco weeds. There seems, however, to be no support for such a theory. When once started, the spread of the disease seems to depend almost entirely upon imitation, one sheep learning the habit from another. On one range in Montana we found 500 locoed sheep in one band. The owner of this band stated that the number of locoed sheep in the band was constantly increasing, and at the same time the worst cases were dying from day to day. During the previous winter he had lost 700 sheep from loco disease. With the sheep on this ranch the habit of eating loco weeds had prevailed for two years. Previous to that time no cases of locoed sheep had been observed, although sheep had been raised upon the range for fifteen years. The habit had not been acquired in consequence of any increased abundance of the loco weed. This plant had been observed in great quantities on the range as far back as could be remembered. Another band of sheep, belonging to a neighboring sheep man, accidentally came in contact with the band containing the 500 locoed sheep during the early spring of 1900. In the early part of May the herder of this second band reported that he noticed two or three cases of locoed sheep in his band. By June 25, when this band of sheep was brought to the shearing shed, the number of locoed sheep in it was found to have increased to 150. This one instance will serve to illustrate how rapidly the habit of eating loco spreads among sheep, and should furnish a forcible argument for removing all cases from the band as soon as discovered. In another part of the State an experienced sheep raiser became nearly ruined financially through his sheep acquiring the loco habit. By adopting the method of immediately isolating the affected sheep, feeding them for mutton, and replacing them with sheep which are free from the loco habit, he has entirely eradicated this trouble on his ranch, although the loco weeds grow there as abundantly as ever.

The fact has generally been observed by sheep raisers that the habit of eating loco weed is usually acquired by young sheep from the age of 4 to 18 months. Old sheep seldom acquire it. The loco habit has frequently been compared to the morphine and chloral habits in man, and in some respects the two habits seem to be comparable. In sheep which have never before eaten the loco weed, large quantities of it frequently cause death within from one to three days. In chronic cases of the loco habit the animal seems to acquire a sort of immunity or increased resisting power against the action of the loco weed. In such cases the first effect of eating seems to be that of a stimulant. This is more easily observed in animals afflicted with the chronic loco

habit when allowed to eat the loco weed after a period of enforced abstinence. Such animals at first become excited, but as more and more of the plant is eaten a depressant or stupefying effect is noticed, such as is characteristic of cases of the chronic loco habit. The habit assumes the form of an insatiable appetite, with the result that the animal continually searches for the loco weed and feeds upon it to the exclusion of other forage plants. Sheep may be seen hurrying with trembling gait from one loco plant to another, devouring each with nervous haste. The habit is sometimes observed already fixed in lambs 2 months old. One of the inevitable results of eating the loco weed exclusively is that the quantity of fodder obtained during the day is insufficient, or, where the weed grows in great abundance, the variety of diet is too small and the nutritive ration is unbalanced.

REMEDIAL AND PREVENTIVE MEASURES.

No specific remedy for the loco disease has ever been discovered. The one definite statement concerning any poisonous principle which may be contained in loco weeds is that made by Dr. Carl Ruedi, who claims to have isolated an acid, which he called "loco acid," from *Astragalus molissimus*, the common loco weed in Colorado. This work has not been corroborated, and it is not at all certain that the same substance will be found to be the active principle contained in the loco weeds of Montana. In the present state of knowledge on this subject the only treatment to be recommended is that of confinement and feeding with nutritious diet. It is sometimes possible for the sheep raiser to move the band of locoed sheep to a range where none of the plants grow. When sheep are unable to obtain the loco weeds a large majority, even of chronic cases, may be fattened and will produce good mutton. In horses which have had the loco habit for a year or more, and which are then kept in stables or pastures where the locoweed does not grow, an apparent recovery takes place, but such animals are apt to show the effects of the loco in various vicious habits, such as kicking or running away without apparent cause. Sheep which have become badly affected with the disease may be inclosed in feeding corrals and fattened for market. A sheep raiser of the Yellowstone Valley discovered in the fall of 1899 that among his sheep he had 1,200 cases of loco disease. These 1,200 sheep were immediately separated from the other sheep and put together in a corral. The same man bought 1,000 other locoed sheep from other sheep men in the neighborhood, and fed the 2,200 locoed sheep for two months upon alfalfa and various roots. At the expiration of this time all of the sheep, with the exception of 50, had apparently made a complete recovery from the loco disease and were in a good condition for market. Of the 50 which were separated from the band the majority were cripples and were removed from the band for that reason. Only 3 or 4 sheep out of the 2,200 failed to

recover from the effects of the loco weed. Other sheep raisers have had similar experience with locoed sheep. There seems to be little doubt that such sheep may be brought to a good condition for market even after being addicted to the loco habit for a whole season.

Although, as just indicated, an apparent recovery may be brought about in locoed sheep and horses, such animals when allowed to run upon the range again almost invariably return to their old habit of eating loco weeds. Animals which have once been locoed are, therefore, not to be considered suitable for stocking the range for the reason that the majority of them will become locoed again, and for the additional reason that other animals will learn the habit and the loco disease will thus spread among the stock.

The recommendation concerning locoed animals which is most in accord with reason and the experience of practical stockmen is to remove immediately all locoed animals from contact with other animals. Following this action it would seem to be advisable, when possible, to place such animals on ranges where the locoweed does not grow and allow them to remain in such situations until winter. During the winter locoed sheep should be fed upon a nutritious diet, and such of them as become fat should be sold for mutton at the conclusion of the feeding period. The few sheep which do not respond to this treatment may as well be killed and skinned, as their only value is that of the pelt. In the case of horses which are kept away from the loco weed for a considerable length of time, the value of the animal is a very uncertain quantity. Such horses may return to the habit of eating loco weeds at the first opportunity, and even if prevented for a time they may develop vicious habits, as already stated. A small percentage of locoed horses apparently make a complete recovery and develop into valuable and reliable animals.

In the case of one large sheep raiser such extensive losses were incurred from sheep eating the white loco weed that the ranch was finally sold to a new comer who was without experience in the sheep business. Sheep were imported from other parts of the State and country to stock this ranch, and no case of locoed sheep has been observed here for the past four years. The immunity which the new owner enjoys from the losses caused by eating white loco weed is, as already indicated, not due to any special precaution on his part nor to any experience which he has had in managing sheep, nor has the plant disappeared from the ranch. His sheep have simply not acquired the habit of eating loco weeds.

Since the loco disease is due to habit it is obviously impossible to apply any such treatment as would be given to a disease which has a definite course or to a case of acute poisoning from death camas or other plants. In the case of poisoning from death camas, water hemlock, or larkspur the result of treatment depends upon the amount of poison

which has been eaten and the promptness with which the remedy is applied. In locoed animals, on the other hand, the stockman has quite difficult conditions to contend with. He may be able, as in the two cases just cited, temporarily to counteract the effect of eating the loco weed. Such cure is, however, only apparent. The habit is formed and the animals will at once begin to eat the plant again if turned out upon the range. A permanent cure therefore, in the ordinary sense of the word, seems to be practically impossible, the loco habit being comparable, as already indicated, to various injurious habits of men, such as habitual drunkenness and the morphine habit. For chronic cases it seems hardly reasonable to expect that any remedy will be devised. Their treatment must apparently proceed on the same principles as the treatment of vicious habits of long standing in man.

SUMMARY.

The white loco weed is a common and widely distributed plant in Montana, being especially abundant on slopes with a northern exposure. It has long been considered by Montana stockmen as the most important loco weed.

Our observations show that eating this plant produces the loco disease, and that the loco habit is common in sheep and horses but rare in cattle. Fatal effects were noted in one acute and several chronic cases in sheep.

Narcotic effects were produced in a rabbit by feeding an extract of the leaves.

The present state of knowledge concerning the exact physiological effect of loco weed is so vague that no specific antidote or medical treatment can be recommended.

Locoed sheep should be removed from the band and fattened for market on alfalfa or other forage plants, as above explained.

The immediate isolation of locoed sheep is advisable in order to prevent the habit from spreading in the band.

It seems desirable to give sheep a regular and abundant supply of salt in order to prevent the development of any perversion of the appetite.

Locoed horses are used to the best advantage as draft animals, but they must be maintained in good condition and prevented from eating loco weeds.

OTHER LOCO WEEDS.

(*Aragallus* spp.)

In addition to the white loco weed a number of species in this and closely related genera are considered as loco weeds in Montana, among which the most important are the silvery loco weed (*Aragallus splendens*

(Dougl.) Greene) (Pl. XI), and the purple loco weeds (*A. blankinshipii* Rydberg, *A. besseyi* Rydberg, and *A. lagopus* (Nutt.) Greene). The last three species resemble each other so closely that it is difficult for anyone not a systematic botanist to distinguish them. The illustrations of *A. besseyi* (Pl. XII) and *A. lagopus* (Pl. XIII), which are given herewith, may well serve to show the general appearance of each.

The silvery loco weed is a handsome perennial, 6 to 12 inches in height, which is soft and hairy throughout, and has narrow cylindrical heads of rather inconspicuous flowers. It is fairly common on dry open prairies and in native meadows throughout the State, blossoming in June.

Aragallus besseyi, one of the purple loco weeds, is a hairy, tufted perennial, 4 to 8 inches high, with numerous long, grayish leaves, bearing 5 to 12 pairs of leaflets, and with short heads of showy purple flowers. It is common near Bozeman, in Spanish Basin, Judith Basin, Smith River Valley, and Missouri Canyon, and in various other places throughout the State, growing preferably in dry, rocky, or gravelly, barren soil, and blossoming in May and the early part of June. *A. blankinshipii* closely resembles *A. besseyi*.

A. lagopus is readily distinguished by its larger, more membranaceous pods, shorter leaves, and smaller number of leaflets.

LUPINES.

(*Lupinus* spp.)

Other names: Blue pea, blue bean, wild pea, wild bean, pea vine.

DESCRIPTION, HABITAT, AND DISTRIBUTION.

These are coarse, silky-haired, perennial herbs, with blue bean-like flowers arranged in showy terminal racemes, which blossom in June and July. The alternate long-stemmed leaves have from 7 to 11 leaflets which radiate from a common point. The fruit is a hairy, several-seeded, bean-like pod, and the seeds are small and somewhat flattened.

The species which interest us here are: *L. leucophyllus* (Pl. XIV), in which the flower clusters are dense and many-flowered on short stems; *L. sericeus* (Pl. XV), in which they are looser and shorter, with fewer but larger flowers and longer stems, and *L. cyaneus*, which is quite similar to the other two species, resembling more nearly *L. leucophyllus*, but differing in its larger and coarser habit.

These plants belong to the pea family, but are easily distinguished from the loco weeds and other common wild species of this family by the character of the leaf. The leaves are compound, and the several parts are all attached to the end of the leaf stem, radiating from this point in different directions. A number of stockmen call these plants

SILVERY LOCO WEED (ARAGALLUS SPLENDENS).

PURPLE LOCO WEED (ARAGALLUS BESSEYI).

PURPLE LOCO WEED (ARAGALLUS LAGOPUS).

LUPINE (LUPINUS LEUCOPHYLLUS).

LUPINE (LUPINUS SERICEUS).

lupines, but perhaps the names wild bean, blue bean, and blue pea are more generally applied to them in Montana. There are a number of species which occur within the limits of the State, but they so much resemble one another that a person who knows one of them will easily recognize the others. On account of their practical importance it seems highly desirable that stockmen should become sufficiently acquainted with these plants to recognize them at a glance, and should learn to call them lupines, since this name is commonly used by botanists and agriculturists in the United States and Europe. Some uncertainty has existed in the minds of a number of stockmen regarding the identity of the loco weeds and lupines. In a few instances illustrations have been noticed in agricultural papers of the white loco weed (*Aragallus spicatus*) which were labeled "loco weed or lupine." But loco weeds and lupines are not at all alike either in their effects or in their appearance. A glance at the photographs of these two plants will show at once the striking differences in their leaf characters and should enable anyone to distinguish them (Pls. IX to XV).

The third of the lupines above mentioned, *L. cyaneus*, is abundant around Livingston and Bigtimber and probably elsewhere in the State. In this paper it is generally not distinguished from *L. leucophyllus*, with which it is practically identical. As regards *L. leucophyllus* and *L. sericeus*, no good evidence could be obtained that the preferred soil and climatic conditions of these two species differ to any noticeable degree. The species, however, are not usually found growing in the same localities. *Lupinus leucophyllus* is found in Yellowstone, Sweet Grass, Park, Gallatin, Madison, Meagher, Jefferson, Deerlodge, Ravalli, Flathead, Teton, Choteau, Lewis and Clarke, Cascade, and Fergus counties. This species is the most widely distributed and most abundant of all lupines which grow in the State. *Lupinus sericeus* was found in Carbon, Park, Gallatin, Meagher, Cascade, Choteau, and Teton counties. Both these species are found ranging from the lowest valleys to an altitude of 8,000 feet. As a rule the lupines do not grow in the flat river bottoms. The usual location in which they are abundant is on sloping hillsides or upon parts of mountain ranges at moderate elevations. In many parts of the State these plants grow so profusely in such localities as to cover the ground completely, and when the lupines are in full bloom, these areas are visible from distances of several miles. The immense tracts of lupines, with their bright blue flowers, are familiar to all stockmen.

HISTORY AS POISONOUS PLANTS.

Circumstances affecting their injurious character.—During the season of 1900 these plants began to bloom about May 20, and the first full pods were collected on June 5. As already stated, the season was

unusually advanced, and these dates are earlier than they would be in an average year.

So far as we have been able to observe, lupines are not very extensively eaten by sheep during the spring and summer. This statement is at least true for normal conditions where sheep are acquainted with the range and are not being trailed or driven. Horses and cattle take kindly to lupines and eat them in large quantities during their immature stages. When sheep are being trailed through strange country, or when they have just been unloaded from cars, and are in a hungry condition, they eat lupines ravenously in any stage of growth. The lupines are not considered valuable as forage plants for sheep until after early fall frosts, or until other forage plants have become dry and uninviting as fodder. In late fall, and especially after early snowstorms, the lupines constitute one of the chief forage plants on some of the mountain ranges. It should be remembered that the leaves of lupines remain green and the plants offer slightly succulent forage after other plants have become dry.

Besides furnishing late green forage on the range, the lupines constitute one of the most important native hay crops, if one judges of the importance of the crop by the amount. In numerous localities over the greater portion of the State, lupines cover the ground completely on continuous areas of sufficient size to enable the ranchmen to cut heavy crops of hay from them. No reports are made which afford a basis for any definite estimate of the total quantity cut in the State. A moderate estimate would place the quantity at several thousand tons per year. In some cases such hay is made up of lupine and a number of other plants in almost equal quantities. Ordinarily, however, lupine hay is cut on areas where the lupines occupy the ground exclusively. Lupine hay is greedily eaten by all kinds of stock during the winter. Large quantities are fed every year, and this has been the case for the past 15 or 20 years.

Lupine hay is cut at different seasons in different years. With the majority of stockmen, who depend upon native wet meadows and lupine for winter fodder, the time of haying depends largely upon the press of other business. It therefore happens that lupine in different years is cut at dates which range from the 1st of July to the middle of September.

Naturally the stage of growth will differ according to the time when the lupine is cut. If the plant is cut during the first half of July, the nearly ripe pods, full of seeds, will be secured in the hay. When the lupine is cut at this time, the pods do not open sufficiently in drying to allow the seed to fall out. In cases where the harvesting of lupine hay is postponed until September, the pods become fully ripe and split open and the greater number of seeds fall out and are not collected with the hay. This is especially apt to be the case if early fall frosts

have occurred before the lupine is cut. It may be stated that as a general rule lupine is not cut until the latter part of August or the first part of September.

There is a striking variation in the quantity of pods containing fully developed seeds in different years. During seasons in which the months of May and June are wet the quantity of pods formed on the lupines is very large. When, on the other hand, these months are usually dry, only a few pods are found on each plant, the vast majority of flowers failing to become fertilized. In a large mountainous State, such as Montana, one would naturally expect to find great local differences in the amount of rainfall and other climatic features, depending partly upon location with reference to the streams, forests, mountains, and partly upon altitude. Corresponding to these differences variations are noticed in the quantity of pods formed on the lupines in different parts of the State.

In observing the feeding habits of sheep, one readily notices that these animals are especially fond of the pods of various native leguminous plants. These pods before becoming mature are usually quite succulent and possess a sweet, pleasant taste, resembling in many instances that of the pods of the cultivated pea. The lupines are among the plants which offer pods of this character. In various parts of the State it was noticed that sheep had fed extensively upon these and the other legumes and that the part eaten was almost exclusively the green pods.

The above observations concerning the native lupines of Montana are made for the purpose of indicating the large extent to which they are used for forage, and also as a foundation for the discussion of their poisonous nature.

Cases of poisoning.—The first case of poisoning from lupines which was brought to our attention occurred in August, 1896. A band of sheep while being moved from one range to another was driven rapidly, and was consequently in a very hungry condition, when it was allowed to feed in a field of lupine for a short time. Within two hours after beginning to eat the lupine a number of sheep manifested violent symptoms of poisoning, and a few died within one hour after the appearance of the first signs of poisoning. Of the 200 sheep in the band 100 had died before the following morning. The season of 1896 was rather late and at the time when the poisoning occurred the lupine pods were fully formed, but the seeds were not quite ripe. In this case the sheep were driven away from the lupine as soon as the first symptoms of poisoning had been noticed and some of the sheep had eaten only small quantities of the plant. About 150 out of the 200 were affected, and as only 50 of these ultimately recovered it will be seen that the death rate was very high.

The owner of these sheep during the same season cut a quantity of

lupine hay during the second half of July. In the winter of 1897 a band of 150 bucks belonging to the same sheep raiser were kept in a covered corral and were fed on cultivated hay. On one afternoon during the winter these bucks were given a liberal quantity of the lupine hay. About three hours after feeding this hay a noisy disturbance was noticed among the sheep. Upon investigation the owner found the sheep in a frenzied condition, and during the night about 90 of them died. No more lupine hay was fed and no more trouble was experienced.

In August, 1898, a horse came under our own observation two hours after having eaten a liberal quantity of lupine hay. The horse became violently ill with symptoms of lupine poisoning, from which it recovered after three days. The history of this case was similar to that of 3 2-year-old colts, which, after receiving cultivated hay during the greater part of the winter of 1897, were fed on lupine hay for two days. All of these died on the second day.

During October, 1898, serious losses of sheep from lupine poisoning occurred in various parts of the State, aggregating about 2,000. About 1,150 died out of a single band of 2,500 sheep, and a number of large losses from the same cause occurred in other parts of the State. These cases occurred just after a snowstorm, while the grass and other plants were covered, the sheep being compelled to eat the lupine as the only plant which stood above the snow at the time. A number of the localities were carefully examined and lupine was found to be the most abundant plant excepting the grass. A study was made of the stomach contents of poisoned sheep, and in all cases lupine was found to be almost the only food material. The stems, leaves, pods, and seeds of this plant were identified in the stomach contents. The great abundance of pods and seeds was especially noticeable. Ordinarily the lupine pods split open and the valves become twisted in such a manner that nearly all of the seeds fall out upon the ground. For some reason an unusually large quantity of seeds had this season been retained in the pods until winter.

During the winter of 1898–99 over 3,600 sheep died from eating lupine hay. This number of deaths occurred among about 7,000 sheep which were affected. The average death rate in investigated cases of lupine poisoning is therefore about 50 per cent. In all cases where severe losses occurred, the lupine had been cut at a much earlier date than usual, the dates given by different sheep men ranging from July 1 to July 20. During this season the lupines had formed an unusual quantity of pods. At the early date at which the hay was cut the seeds were fully formed, but the pods were not yet dry enough to open and scatter the seeds.

The most extensive losses of sheep from feeding hay occurred in the Judith Basin. In all cases the hay, a part of which had been left

unfed, was examined and found to consist almost exclusively of lupine (*Lupinus sericeus*), with full pods containing ripe seeds. At one ranch on Sage Creek two tons of lupine hay was fed to a band of 2,000 sheep, with the result that 700 of these sheep died within a period of forty-eight hours. In this case the feeder did not believe at first that the lupine was the cause of poisoning. In order, therefore, to show the courage of his convictions he tried the experiment of feeding about 200 pounds of lupine to 50 sheep from another band. Some of these sheep fell dead before finishing their meal, and altogether 28 died within a period of twenty-four hours. As occasion arose the remaining portion of the lupine hay was applied to other purposes. A small quantity was used as a covering for a lamb shed in the following spring. During a windstorm a part of it was blown off on the ground and eaten by a number of rams, 3 of which died.

At another sheep ranch on Buffalo Creek a band of 2,500 sheep were fed lupine hay, and 900 out of this number died within forty-eight hours after eating the hay. The remainder of the stack was left standing, surrounded by a fence. During December, 1899, the fence around the stack became broken down at one point, and another herder, while driving a band of sheep by the stack, allowed a part of the band to enter the inclosure and eat some of the lupine hay. The sheep were soon driven out of the inclosure, but many of them showed signs of poisoning, and 100 died. In this case, in the same manner as on Sage Creek, a quantity of this hay was used for covering a sheep shed, with the result that some of it blew off and caused the death of 7 sheep.

In Deerlodge Valley an old and experienced sheep raiser suffered a loss of 700 sheep from eating lupine hay. The owner of these sheep had cut lupine hay on the same ground for five or six years, and had fed it without any bad consequences. During these years the hay had always been cut during the earlier part of September. The material which caused the disastrous poisoning just mentioned was cut during the first half of July. Only a small part of the lupine which was intended for hay was cut at this early date, other work interfering with haying, and the remainder was cut in September. That which was cut at the earlier date was stacked in a temporary manner, and that which was cut in September, therefore, came to occupy the upper portion of the stack and was naturally the first to be fed to the sheep. This hay did not cause any cases of poisoning, but the first feed from the hay which was cut in July caused the death of 700 of the sheep. From this case it is evident that the poisonous or nonpoisonous nature of lupine hay depends partly upon the stage of growth at which it is cut.

A sheep owner near Birdtail Pass had 500 sheep poisoned from eating lupine hay, 160 of which died. In this case, as in the previous

one, the sheep raiser had had some experience in feeding lupine hay, but had never before had any losses. The lupine was cut in July, at a time when the seeds were still contained in the pods.

The evidence in regard to lupine hay proves conclusively that such hay is exceedingly dangerous when cut in full pod, with ripe seeds. The experience of a number of sheep men indicates, on the other hand, that lupine cut late in the season, after the seeds have fallen out, may be fed to sheep with impunity. The case referred to in the Deerlodge Valley may be cited as proof of both propositions. Experiences similar to this have been had by a number of sheep raisers in other parts of the State. On Buffalo Creek, in the Judith Basin, a quantity of lupine hay growing near that which caused the loss of 900 sheep, already referred to, was cut in September of the same year, and was fed to sheep without causing any poisoning.

Instances have already been related of sheep poisoning from eating lupine while growing upon the range, and other instances have been noted of sheep eating lupine upon the range without becoming poisoned. In these experiences, as in those with lupine hay, the general conclusion is indicated that lupine is poisonous only when containing ripe seeds. Our observations and experiments show conclusively that lupines are harmless during the earlier stages, before the pods have been formed, and also during the later stages, after the seeds have fallen out. Lupine hay cut during the month of July seems to be exceedingly dangerous. It would obviously be impossible to state in advance the actual dates at which lupines become poisonous, and the date in the fall at which they cease to be poisonous. Since, therefore, it is practically impossible to define these periods accurately, it would seem doubtful wisdom to cut lupine for hay at all, at least where other hay can be obtained.

A few other serious cases of sheep poisoning from eating lupine on the range may be briefly described. In one case a few carloads of sheep, which were shipped by train, were unloaded near the Mullen Tunnel, at an altitude of about 6,000 feet. The shipment was made in July, and at the time when the sheep were unloaded they were in a ravenously hungry condition. As lupines constituted the most conspicuous forage material accessible to the sheep, they filled their stomachs with them, eating great quantities of the pods. Within a few hours a large number of the sheep showed the symptoms of poisoning and 400 died.

During the same month a band of 2,000 sheep was trailed over the Birdtail Pass. Lupines grew abundantly in this locality, and the sheep fed almost exclusively on these plants. About 1,000 of these exhibited signs of poisoning, and 700 of them died from the effects of lupine.

Perhaps the most disastrous case of sheep poisoning ever known in

Montana occurred on June 28, 1900, about 5 miles west of Livingston. Two bands of sheep, each numbering 3,000, were being trailed westward from Livingston. These sheep had been imported from Oregon about a week previous to the time of poisoning, and had been allowed to graze during this week upon rather short, dry grass in the vicinity of the Livingston stock yards. On the day before the sheep were started on the trail they were liberally salted. On the first day of the drive the sheep traveled about 5 miles, and the two bands were camped for the night on opposite sides of a small stream. Both bands of sheep were watered in the same stream and at exactly the same place. After watering, one band was driven across the creek and camped on a bench about 30 feet higher than the stream. The other band was camped on the same side of the stream from which it was watered. At the time when the herders went to sleep for the night, about 9 p. m., both bands of sheep were in good condition. On the following morning nearly all of the 3,000 sheep which had been driven across the creek manifested symptoms of poisoning, and several hundred of them were dead. Out of this band 1,900 ultimately died. The greater number of deaths occurred on the first day, but the sheep continued to die for a period of three days. During this time the sheep had little appetite and ate almost nothing. No deaths occurred in the band of sheep which was camped on the other side of the stream.

Malicious poisoning was at once suspected as the cause of this unusually heavy loss. A number of persons visited the place where the sheep were poisoned and made an examination of the range for the purpose of discovering, if possible, any poison which had been placed maliciously upon the range. No such poison was to be found, although careful examination was made immediately after the poisoning occurred. Although suspicions were entertained by a number of persons against a suspected enemy of the owner of the sheep, these suspicions did not rest on any facts which could be supposed to corroborate them.

A careful study of the circumstances of this case disclosed the following facts: The sheep were driven about 4 miles during the previous day and ate the plants along the road near the Northern Pacific tracks. The plants which grew most abundantly along this course were lupine (*Lupinus cyaneus*) and milk vetch (*Astragalus drummondii*). The sheep ate both these plants extensively. Both were in full pod, and the sheep seemed to prefer the pods. It was observed that the pods had been stripped off the flowering stems, leaving the rest of the plant untouched. Of the Astragalus the sheep ate both the leaves and pods. The latter was of a much finer and more delicate nature than the lupine in this locality. The lupines were unusually large and woody, attaining a height of from 2 to 3 feet. The facts thus far noted, however, would hardly justify the belief that the quantity of the lupine which

had been eaten was sufficient to cause the death of so many sheep, with a death rate of 63 per cent, nor account for the fact that only one band of sheep was poisoned while the other remained entirely unharmed. Yet post-mortem examinations, made on a number of sheep, one of which had just died, revealed large quantities of lupine pods and seeds in nearly every stomach, and no evidence of any other poisonous substance was to be found. The results of the first examinations were confirmed by a second visit to this locality several days later for the purpose of making further examination of the stomach contents. Large numbers of carcasses still lay on the ground in a badly decomposed condition, but it was a comparatively easy matter to demonstrate the presence of lupine pods in every stomach. About 75 sheep were examined for this purpose. The fact that lupine pods are exceedingly hard and resist decomposition for weeks, combined with their characteristic shape, makes their identification a very easy matter.

Further facts were developed, however, which furnished a satisfactory explanation. A large quantity of lupine grew on the side of the creek where the band which was poisoned camped for the night, while on the other side of the creek where the other band camped no lupine was found. The first band was driven across the creek about 8 o'clock in the evening and grazed for some time before lying down. They thus had opportunity to eat the lupine which grew on that side of the creek, and an examination of this lupine showed that the pods had been stripped off.

The immunity of the second band is explained by the fact that with the exception of the first mile of the drive, this band took a course different from that of the first band, though parallel with it. No lupine grew on the first mile of the drive where both bands followed the same course, and it so happened that the course of the second band for the rest of the distance led through fields where no lupine was to be found. The most abundant plant along this course was *Astragalus drummondii*, a good forage plant, of which the pods had been eaten extensively by the sheep. While the first band of sheep, therefore, had opportunity to eat the lupine, not only near its camping ground but at several other points along the course of the drive, the second band had no opportunity of eating it. At one point in the course of the drive, indeed, all the sheep passed through a small area of another species of lupine (*L. pseudoparviflorus*); but this species had formed scarcely any pods and was not eaten by the sheep.

EXPERIMENT.

On June 26 two sheep were fed each 150 medium-sized lupine pods which were well filled with nearly ripe seeds. The sheep ate the pods readily and seemed to manifest a fondness for them. Both sheep became frenzied in about forty-five minutes after eating the lupine

pods and died about one hour later. The symptoms in these two cases were the same as those observed above and were of the acute form.

SYMPTOMS OF POISONING.

The symptoms of lupine poisoning are tolerably uniform and are so well known in Europe that chronic lupine poisoning has been given the name lupinosis. Both acute and chronic forms of the disease are frequently referred to by European writers. In the United States, however, the chronic form has thus far not been recognized. The symptoms observed in cases of lupine poisoning in Montana are practically identical with those described by European writers as caused by European species of lupines. There is always to be noticed an acute cerebral congestion accompanied from the start with great mental excitement. During this stage the sheep rush about in different directions, butting one another and other objects. In some cases it was observed that the sheep ran toward the herder or other persons, but there is probably no significance to be attached to such actions. The first stage of frenzy is followed by a second stage, characterized by pronounced irregularity of movement, violent spasms, and falling fits. In the large proportion of cases collapse and death occur within from one-half to one and one-half hours. During the attack the pulse is strong and irregular. After the animal is no longer able to stand, attacks of convulsions follow one another at short intervals. These convulsions resemble to some extent those caused by strychnine. Universally in lupine poisoning the excretion of the kidneys is much increased and sometimes it is bloody. In extensive cases of poisoning by lupine it is to be observed that a number of the sheep linger on for from two to four days. In these lingering cases the symptoms do not follow one another so rapidly and do not assume so violent a form. After the first day a striking weakness of the pulse and slowness of respiration are manifested.

Post-mortem examinations of the sheep poisoned by lupines revealed conditions very similar to those found in the acute cases of loco disease, already described above, with the exception that in loco disease the kidneys were not affected. The lungs were slightly congested, but this condition was not so pronounced as in cases of larkspur poisoning. The cerebral membranes were in all cases congested. In the more violent cases small blood vessels had been ruptured in various parts of the body, which may have been due either to increase of blood pressure or to the struggles of the animal.

REMEDIAL AND PREVENTIVE MEASURES.

No remedies have been tried in cases of stock poisoning from eating American species of lupine, and we can not, therefore, recommend any treatment which is based on personal experience with these plants. It is possible that liberal doses of a mixture of potassium permanganate

and aluminum sulphate, given as previously directed, might destroy the lupine alkaloids in the stomach and prevent the development of the most violent symptoms. It is advisable to administer this remedy, especially in cases which are observed immediately after the manifestation of the first symptoms. The physiological effects of the poison may be controlled by the hypodermic use of morphine or other sedatives. In view of the extensive losses caused by eating lupines in a ripe condition, both on the range and as hay, it would seem advisable to abandon the use of these plants for forage, at least until experiments have been conducted to determine more accurately the periods when such plants are not poisonous. It is certainly dangerous to feed lupine hay to sheep, especially if such hay contains seeds in a ripe or nearly ripe condition. It is recommended, therefore, that lupines should not be cut for hay, if they are to be cut at all, until the pods are sufficiently matured to allow the seeds to fall out before the hay is stacked. This period will usually fall after the middle of August. In case any doubt is entertained concerning lupine hay which has been stacked, it is advisable to feed liberal quantities of such hay, from different parts of the stack if cut at different times, to 1 or 2 sheep, in order to ascertain its true character, before feeding it in a wholesale way.

It has often been observed by stockmen that cattle and horses may safely be allowed to eat lupine hay which has been shown to be poisonous to sheep. It is not always safe to allow cattle and horses to eat such hay, but these animals as a rule avoid the lupine pods and eat only the stems and leaves. This is perhaps the only explanation which can be suggested at the present time for the observed fact that lupine hay may be harmless to cattle and horses and at the same time poisonous to sheep.

SUMMARY.

Lupines are extremely abundant throughout the State, especially on slopes or foothills and on mountain ranges.

During the past four or five years certain cases of poisoning in Montana and a few other Western States have been vaguely attributed to lupines.

Our observations and experiments showed conclusively that lupines, in certain stages of growth, have caused fatal poisoning in sheep.

Lupines are cut for hay in Montana on an extensive scale, and when containing ripe seeds such hay is exceedingly dangerous to stock. If used at all it should be used only when it is known to be free from ripe or nearly ripe pods.

No remedy for poisoning by American lupine has been ascertained, but the trial of potassium permanganate and aluminum sulphate is recommended.

ERGOT (CLAVICEPS PURPUREA), IN HEADS OF WILD RYE GRASS.

POISONOUS PLANTS OF LESS IMPORTANCE.

ERGOT.

(*Claviceps purpurea* (Fr.) Tul.)

Ergot is a parasitic fungus frequently occurring in Montana on a variety of grasses, among which the following may be mentioned: Four species of wild rye grass (Elymus), three species of meadow grass (Poa), six species of couch grass (Agropyron), prairie June grass (*Koeleria cristata* (L.) Pers.), and reed canary grass (*Phalaris arundinacea* L.). Ergot most frequently infests wild rye grass (*Elymus condensatus* Presl) and bluejoint (*Agropyron spicatum* (Pursh) Scribn. & Sm.). The form in which ergot is commonly seen is that of a black, straight or slightly-curved spur from one-fourth to one-half inch in length in the fruiting head of the infested grass. (Pl. XVI). Ergot is found throughout the State, wherever wild rye grass or bluejoint grows. There are extensive native meadows of bluejoint in the State which are annually cut for hay. Bluejoint hay is known to be highly nutritious and is greatly valued by stockmen, some of whom consider it better than alfalfa, clover, or timothy. Wild rye grass grows very abundantly in some locations, but it is not so extensively cut for hay as the bluejoint. As is well known, the wild rye grass has a habit of growing in large bunches, and seldom covers the ground completely. The ground where it grows is, therefore, rendered somewhat uneven, and the difficulties of cutting the grass increased. Some years the wild rye grass is much worse infested than other years. During such seasons the black spurs of ergot are a conspicuous feature of the heads of this grass. In ordinary seasons the ergot spurs are fully formed by the middle of August and remain in the heads of the infested grass until late in autumn.

Several cases of ergot poisoning came to our notice. In one of them a horse, while being driven from Helena to Bozeman, was fed on the first night of the trip with wild rye grass hay which was badly infested with ergot. On the following day the left hind leg appeared somewhat stiff and moist with cold sweat. During the second day the leg became badly swollen and gangrene of all the tissues became apparent. The skin of the leg and a considerable portion of the muscular tissues were sloughed off before the death of the animal, which took place on the third day. Cases of the ordinary, slow-acting ergotism were observed in both cattle and horses. During the season of 1898 one of us had opportunity of observing several cases of what was apparently another form of ergotism in horses. The animals had eaten considerable quantities of ergot in bluejoint and wild rye grass hay. The symptoms, which will presently be described, were manifested within twenty-four hours after eating the ergotized hay, and it

should be stated that no other conditions were present which could account for the sickness and death of these animals. The symptoms manifested were the same in all cases. The first sign of poisoning which was noticed was fatigue and indisposition to work. Soon afterwards a cold sweat was to be observed on parts of the body, particularly the neck. A paralytic condition soon began to manifest itself, beginning with the tongue and muscles concerned in the act of swallowing and becoming rapidly generalized until the whole body was involved. In two cases, which were observed from the time of the first signs of poisoning until death, the paralysis of the tongue and muscles of the throat was noted about two hours after the first symptoms appeared. From this time on the animals were unable to swallow. The paralysis progressed rapidly and death resulted within six or eight hours in the two cases. There were no cerebral symptoms or mental excitement in these horses. The pulse was at first normal but gradually became weaker until it was scarcely distinguishable. Respiration was very slow and deep. The horses had a subnormal temperature during the greater portion of the time. The remedies which were tried in all cases included alcoholic stimulants, blistering the throat, and strychnine. Out of six cases treated in this manner only two recovered. The experiments indicated that it is practically impossible, or even dangerous, to give remedies in such cases by way of the mouth, except during the earliest stages, before the paralysis of the throat has been developed. In one case a pint of whisky was given as a drench, and this stimulant was followed by two one-fourth grain doses of strychnine administered hypodermically. At the time when this treatment was given the animal was so badly paralyzed that it was unable to stand. The treatment seemed to benefit it temporarily, and it got upon its feet. After walking about for half an hour the paralytic symptoms returned, and the horse again lost control of the tongue, gradually also of the sympathetic voluntary muscles, and died in an apparently semiconscious condition.

One of the well-known effects of overdoses of ergot is the production of abortion. In several parts of the State numerous cases of abortion have occurred simultaneously or in close connection on the same ranch. Some of these outbreaks, especially among horses, have proved to be of an infectious nature and the disinfectant treatment suitable for this disease was followed by good success. In other instances, however, outbreaks of abortion were evidently not due to infection, and were not traceable to any cause except the eating of ergot in hay. An examination of the hay in such cases disclosed the presence of ergot in abundance.

In discussing the problem of ergotism with various stockmen it was found that in many instances the nature and appearance of ergot was not at all understood. A number of stockmen had noticed the spurs of

COW COCKLE (VACCARIA VACCARIA).

ergot in the heads of different grasses, and had come to the conclusion that these ergot spurs were the seeds of the grass in question. The general experience of stockmen in the State with bluejoint is that this grass seldom forms seeds in the native meadows. It was thought, therefore, by some that the conspicuous ergot spurs were simply the rare examples of its seeds. It would be easy, however, for anyone to convince himself that the ergot spurs are not grass seeds. If one of them be crushed, it will be found to consist of a black mass which is the sclerotium tissue of the fungus, of which the spurs may be called the fruit. These spurs are usually about half an inch in length and are so conspicuous as to be visible for several yards. It would seem, therefore, a simple matter for the stockmen to avoid cutting badly infested areas of grass for hay. Fortunately ergot is much rarer on bluejoint than on wild rye grass, and since the latter is used only to a limited extent for hay, it would not work any particular hardship to the stockmen to avoid the use of wild rye grass whenever it is infected with ergot.

It seems possible that the disease of sheep known as "mountain itch" may be due to eating grass affected with this fungus and not to the mechanical effect of cactus spines, as is thought by some sheep men. A more thorough study of ergot may show that it is one of the principal sources of loss throughout the State.

COW COCKLE.

(*Vaccaria vaccaria* (L.) Britton.)

Other names: Cow herb, soapwort, China cockle, spring cockle, cockle.

A smooth much-branched annual 1 to 3 feet high, with mucilaginous juice, lance-shaped leaves, and pale red flowers in diffusely branched clusters which blossom in May and June (Pl. XVII). This species is rapidly becoming a noxious weed throughout the State, especially in cultivated soil. The plant is of European origin and is gradually becoming established in all parts of the United States, the seeds being carried in grain and in other ways.

The cow cockle grows in waste places, in cultivated soil, and on sandy hillsides in Montana, specimens having been collected in Lewis and Clarke, Cascade, Teton, Sweet Grass, Gallatin, Madison, Yellowstone, Flathead, and Custer counties. This and not the corn cockle (*Agrostemma githago*) is the plant referred to by the millers of Montana when they speak of cockle. From the occurrence of the seed in spring wheat, however, it is called spring cockle. This distinguishes it from the ordinary corn cockle which occurs sparingly in Montana in fall wheat. Under the name of cockle, seeds of this plant were, at our request, furnished for identification by Mr. E. B. Lamme, of the

Bozeman Milling Company. Mr. Lamme stated that it was much more easily screened out of wheat than is the true cockle and that the amount obtained yearly at his mill was about a ton. The seeds, along with an excess of broken grains of wheat, are sometimes sold as screenings for chicken feed and often thrown away. In gross appearance the seed is spherical and much like that of mustard, but nearly twice as large. A magnifying glass discloses a regular, finely granulated surface instead of a smooth one, and on biting the seed it is at once observed that its coat is harder and thicker and that the kernel lacks the characteristically pungent taste of mustard seed.

A considerable amount of the wheat from Gallatin Valley and the adjacent regions which is milled at Bozeman contains cow cockle seeds. Miss Edna Maynard, a graduate from the botanical department of the Montana Agricultural College, informed us that at Ennis a man who had tried to raise wheat for flour found his wheat was not millable on account of its large content of cockle. It is quite probable, however, that in addition the wheat was soft. Mr. Lamme states that the soft wheat containing the seed is of no value for milling, but that the seed is easily removed from hard wheat. It occurs in barley and oats also, but is easily screened therefrom.

As a weed, pure and simple, it is getting to be nearly as bad in Montana as mustard or charlock (*Brassica arvensis*), but it does not yet crowd wheat out like the latter. Cow cockle has spread with alarming rapidity through the Northwest, becoming one of the worst weeds of that section. In this way it has undoubtedly grown to be worthy of far more consideration from an economic standpoint than it ever deserved in Europe or in Asia. Professor Crandall[1] states that it was introduced into Colorado for ornament as early as 1874, and that it is now sometimes abundant in gardens and among crops throughout that State. It is widely disseminated in the fall by the tops of the plants being blown about by the wind like tumbleweeds. In his bulletin[2] on noxious weeds, Prof. James Fletcher, of Ottawa, states that the cow cockle was first introduced into Manitoba from Europe, and that it has spread rapidly over the southern portion of the province and has been detected in many parts of Manitoba and the Northwest Territories. It was introduced at Bozeman, according to Mr. Lamme, about 1885, when the Northern Pacific Railroad was extended into the valley. Its distribution in America is given by Britton and Brown[3] as from Ontario to British Columbia, south to Florida and Louisiana, and in the Rocky Mountains. It has been found also in California, and in the West it promises to become more abundant wherever it grows.

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[1] Colorado Weeds, Bul. 23, Colo. Expt. Sta., p. 8. 1893.

[2] Govt. N. W. Territories, Dept. Agr. Bul. 1, p. 15. 1898.

[3] Ill. Flora of the Northern United States, Canada, etc., vol. 2, p. 18. 1897.

Very little seems to have been written concerning the action of the plant on the animal organism. Nicolai Kruskal[1] states that the plant contains a poisonous saponinlike substance, but does not state in what part of the plant it is to be found or is most abundant. Britton and Brown in their Flora state that the name "cow herb" was applied to the plant in allusion to its value for forage. Cornevin,[2] a French authority on poisonous plants, does not include the cow cockle in his treatise, but states that animals refuse to touch *Saponaria officinalis*, a very closely related species. Mr. Lamme says that when fed with screenings chickens reject the cockle. Miss Maynard corroborates this statement, and says that hogs and sheep will eat the screenings, but that horses reject the cockle.

No cases of stock poisoning were reported, but, as the seeds are sometimes rejected as food, it was concluded that there must be a reason for it. It was thought also that, since the seed has been but recently offered to animals in large quantity, the toxic effects, as in many cases of corn cockle poisoning, might have been mainly of a chronic order and on this account easily overlooked. An investigation was therefore started and 119½ grams of the finely ground seed was mixed with an equal weight of distilled water, heated for two hours at a temperature (60° C.) somewhat less than commonly used for scalding, allowed to stand at the ordinary room temperature overnight, and then filtered under pressure through a strong linen bag. The filtrate was a thick, milky, and very frothy fluid, which rapidly darkened on exposure. It, as well as the residue, had a sharp pungent and repulsive odor and taste. On dilution with water it frothed a great deal even in very dilute solutions, thus exhibiting one of the most characteristic tests of the sapotoxin-like compounds. The frothing was, indeed, so marked that it was at first impossible in water solution to measure off any given amount, but after long standing the bubbles disappeared, leaving a clear solution. Only 31 grams of the fluid extract was obtained (on June 5) from the 119½ grams of seed. This quantity is not, of course, the full proportion of extract from the entire quantity of seed, but is equivalent to that from about 31 grams, the remainder being kept in solution in the water mingled with the finely ground seeds. After the filtrate was secured the residue was dried and then put to soak with 50 per cent alcohol.

Experiment 1.—On June 6, 7 grams of the water extract, representing approximately 7 grams of seed, was fed at 12.17 p. m. to a white rabbit weighing about 3 pounds. At 2.20 the pulse was normal, but the respiration was slow and shallow. The rabbit was lying prostrate on the ground with the head stretched out so that the throat also was

[1] Ueber einige Saponinsubstanzen, Arbeiten des Pharmakol. Inst., Dorpat, vol. 6, p. 7. 1891.

[2] Les Plantes Vénéneuses, p. 262. 1893.

resting on the ground. It would move only when strongly urged to do so.

At 3.12 an additional amount, about 14 grams, of the extract was administered. At 3.16 the rabbit was in a very bad condition. Its heart was in a constant flutter and it sneezed hard, almost continuously, for several minutes. At 4 and 5.30 it was torpid and sleepy, but was able to move actively when sufficiently urged. At 5.40 it ate a few mouthfuls of grass. At 9 o'clock the next morning its appetite was still poor and its pulse and respiration both higher than normal. It could walk a little, but would not do so of its own accord, the stomach in particular appearing heavy, and being so much paralyzed and distended that it impeded progress. A small amount of exercise, such as that involved in walking 5 or 6 feet, caused very rapid breathing. At 9.20 it had eaten very little. Another violent coughing and sneezing spell then came on, causing much uneasiness. On June 8, the rabbit's respiration and pulse had greatly improved, but it was still unusually stupid. On June 9 it was still somewhat sickly in appearance. No further observations were made.

Experiment 2.—The residue from which the water extract used in experiment 1 was prepared was first dried and then allowed to stand in contact with 50 per cent alcohol for a day or more, after which it was filtered under pressure. Twelve cubic centimeters of extract, the equivalent of approximately 12 grams of the seed, was filtered off. On June 10, 1½ c. c. of this was injected hypodermically into a 32-ounce rabbit at 12.50 p. m. The animal was almost immediately attacked with a violent spasm, accompanied with rapid breathing and a partial paralysis of the rear quarters. At 1.45 the paralysis still continued. The animal had no desire to move and when compelled to do so its hind legs dragged heavily.

Mr. Irvin Cockrell, who had assisted in the experimental work, continued the observations on this rabbit. At 5.5 p. m. on the same day the pulse and respiration were much weaker, but regular. The animal was unconscious and its body was becoming rigid. At 5.30 it was still weaker; the pulse was slow and irregular and the respiration about nine times a minute. The body became more and more rigid, and even before death, which occurred at 5.40, it was as stiff as animals become after death. The pupils were contracted throughout the experiment.

An inspection of these two experiments shows that the toxic substance is at least partially soluble in both water and alcohol, that the water solution froths upon brisk agitation, and that the physiological effect is both immediate and remote, as is the case with the poisonous sapotoxin-like bodies found in many poisonous plants such as the seed of corn cockle (*Agrostemma githago*) and the root of bouncing bet (*Saponaria officinalis*).

SWAMP CAMAS (ZYGADENUS ELEGANS).

Some animals with sound digestive tracts will accustom themselves to feeding on vegetable products containing these compounds, while animals of the same kind having ulcerated digestive organs will often succumb to them. In using such food stuffs regularly one also runs a considerable risk of inducing chronic poisoning, the symptoms of which have not been well investigated. Under this influence the stock will rapidly decline, or fall off in flesh, the reason not being usually apparent to the common observer.

No antidotes were experimented with. On general grounds, however, it would be well to use the permanganate solution if it is probable that some of the seeds still remain in the stomach. The application of soda will probably do no good. Oils and demulcent drinks should be administered as quickly as possible, but for further treatment the service of a veterinarian should be obtained. Cow cockle has a shallow root and consequently may be easily pulled out of the soil, but when it is abundant it should be killed off by summer-fallowing, a practice which is often made use of in Montana.

SWAMP CAMAS.

(*Zygadenus elegans* Pursh.)

This species resembles death camas, but is distinguished from it by its taller stature, larger flowers, and wider leaves, which sometimes attain the width of a half inch (Pl. XVIII). The flowering of death camas begins in different years from the 1st to the 15th of May; swamp camas blooms about two weeks later.

The distribution of swamp camas in Montana is less extensive than that of death camas, but the plant is extremely abundant in certain limited areas. It is found in the Judith Basin, near Grafton, Utica, Ubet, and Lewistown. Other localities in the State in which it was found were Bozeman, Spanish Creek, Sixteenmile Creek, Helena, Mill Creek, Deerlodge, Columbia Falls, and on Shields River. Its general range is very wide, extending from New Brunswick to Alaska, and south to Vermont, New York, and in the Rocky Mountain region to New Mexico. The general appearance of both species of this genus varies to a considerable extent, depending upon the amount of moisture in the soil where they grow. Swamp camas grows in wet meadows and in much moister localities than those in which death camas is ordinarily found. When growing in wet meadows it is usually in full seed at the time when the grass is cut. On one sheep ranch a few tons of hay had been cut in the fall of 1899 and it was intended to feed the hay during the fall and winter. This hay proved on the first feeding to be poisonous to sheep and no more of it was fed out. An examination of the remaining portion of the hay in the stack showed that large quantities of swamp camas were present. No other plant

which could be considered poisonous was found in the hay. An examination of the meadow showed a similar condition there, namely, the presence of a considerable quantity of swamp camas, but of no other plant of a poisonous nature. It should be observed that this species of Zygadenus does not dry up so rapidly as does death camas, and being coarser the vegetative portion was conspicuous in the hay. This was the only case observed where the plant was suspected of poisoning hay.

On another ranch in a different part of the State six cattle were poisoned while feeding in a wet pasture where swamp camas grew in abundance, and two of the number died. The symptoms manifested by these cattle were as nearly identical with those displayed by sheep in cases of poisoning by death camas as the natures of the two animals would permit. Postmortem examination of these two animals revealed the same anatomical conditions as those found in sheep which had died from eating death camas. Larger quantities of swamp camas were found in the stomachs of the dead animals. The observations thus far made on this species seem to indicate the presence of a poisonous principle similar to that found in death camas.

SHOWY MILKWEED.

(*Asclepias speciosa* Torr.)

A perennial 2 to 5 feet high, with a simple stem, milky juice, large, opposite, entire leaves, purplish flowers in spherical clusters, and large pods containing numerous seeds with fine, silky hairs (Pl. XIX). The plant blossoms in June and July, and is found in wet bottom land and along damp railroad embankments at Helena, Ravalli, and various points in the Bitter Root Valley, and in Beaver Head, Gallatin, Choteau, Flathead, and Sweet Grass counties, and along the Yellowstone Valley. The general distribution of this species is from Nebraska to Arkansas and across the continent westward.

On June 1 12½ grams of the budding top, including the stem and several leaves of the plant, collected May 30, was offered to a small rabbit weighing about a pound, which had been deprived of its breakfast. All of the material, which had been kept in a closed collecting can and was turgid with milky juice, was eaten within a couple of hours without any ill effect arising therefrom. Thirty grams more was offered in the evening of the same day to the same rabbit. All of this, save a small portion of the juicy stem weighing 12 grams, was eaten by the next morning. No ill effect having been noted, 92 grams, including the whole length of the plant, was offered to the same rabbit the next day. The animal, although it had been deprived of its food since noon of the preceding day, merely nibbled at the leaves. In other ways, also, it exhibited an evident dislike for the plant. After a few hours 57 grams of the badly desiccated plant remained uneaten.

SHOWY MILKWEED (ASCLEPIAS SPECIOSA).

An inspection of the latter showed, however, that about two leaves and a small portion of the basal part of the stem was all that had been eaten. The apparent loss of 35 grams was therefore almost entirely due to desiccation. No ill effect was noted, but the experiment showed conclusively that the plant was objectionable.

With the hope of obtaining some idea of the symptoms of poisoning, all of the remaining portions of the plants gathered May 30 were ground in a sausage mill on June 5, and the olive-green, slightly turbid juice expressed therefrom was fed to another rabbit. The plant material used had been retained in a tin box, as above mentioned, and was still nearly as turgid with milky juice as when fresh. A quarter ounce was injected through the mouth into the stomach of a vigorous 1-pound rabbit at noon, June 6. After three hours the effect exhibited had been so slight that one-half ounce more was given. An hour afterwards the animal appeared anxious, and was easily frightened and much disinclined to move. The respiration was rapid. The head was also throbbing and pulsating in a way which indicated that the brain was badly affected by the poison. This throbbing of the head continued with nearly total loss of appetite until 5.30. It was still apparent the next morning. The respiration and pulse were then rapid and the animal was not at all vigorous. Nearly the same conditions prevailed on June 8 and 9. On June 12 it had recovered its normal condition to a great extent and was used for another experiment.

Twenty-five minims of the expressed juice from plants collected in the evening of June 14 were administered hypodermically on June 16 to a 26-ounce rabbit, but no marked symptoms resulted.

The woolly-pod milkweed (*Asclepias eriocarpa*), a plant which, on account of the great similarity between the two, is often mistaken for the showy milkweed in California, is especially dreaded by California sheep men on hot days when they are obliged to drive their flocks through barren valleys where there is little water, because the succulence of the plants tempts the animals to quench their thirst by eating them. The remedy employed is to send someone a few days ahead of the sheep to cut the plants down. The dried herbage may still be poisonous, but the sheep are not tempted to eat it.

No experiments were made to determine the value of the permanganate mixture as an antidote, but it could probably be used to great advantage.

CALIFORNIA SWAMP HELLEBORE.

(*Veratrum californicum* Durand.)

A stout herbaceous simple-stemmed perennial 2 to 7 feet high, with a fleshy root 3 to 6 inches long, large plaited leaves of varying size, and a large, branched, terminal cluster of many small greenish-yellow flowers which bloom in June and July. In Montana the only

known localities for this plant are Belt Creek, Little Belt Mountains, Bridger Mountains, Bozeman, Deerlodge, and Loto Creek. Outside the State the plant grows from Colorado to Wyoming, northern California, and Oregon. The root and leaves have been frequently reported as having caused death to cattle and horses. Both the commoner Western and Eastern species of Veratrum are known to be poisonous. The only doubtful question in connection with the importance of this species as a plant poisonous to stock is that of the extent to which it is eaten. We have never observed stock eating it, although this may frequently happen. The symptoms of poisoning as given by stock owners are dizziness, reeling, impaired vision, frothing at the mouth, and convulsions.

The distribution of this plant in Montana is very limited, and for this reason it could be easily avoided. Since it grows only on mountains, it is quite unlikely that it will cause sheep poisoning. It is altogether too large and coarse for sheep to forage upon at the time of year when these animals are allowed on mountain ranges. The only animals reported as having been killed by it are horses and cattle. As already stated, it is undoubtedly poisonous and it is therefore desirable that stockmen should become acquainted with the appearance of the plant and its distribution. The species is found most abundantly on the Smith River slopes of the Big Belt Mountains below the Duck Creek Pass. On Belt Creek, near Monarch, and in the Bridger Mountains it is also rather common. In all of these localities this plant could be exterminated with a moderate amount of labor, digging or cutting off below the ground with a spud being perhaps the best method. Prevention by this means is the best remedy which can at present be offered. No material was obtained for experimental purposes, as our attention was fully occupied with plants much more easily accessible. Experiments were, however, made with the poisonous alkaloid veratrine which, judging from analogy with the common swamp hellebore of the East (*V. viride* Ait.), probably exists in the plants, especially in the root. The object of the experiments was not to observe the symptoms, but simply to determine whether or not the mixture of permanganate of potash and sulphate of aluminum would serve as a good chemical antidote. From chemical experiments made by Dr. Moore with the permanganate and veratrine chloride, he concluded that the permanganate would be of no value as an antidote for this alkaloid. Test-tube experiments made by ourselves with a 1 per cent solution of Merck's sulphate of veratrine and a 1 per cent solution of the permanganate with a half per cent solution of the aluminum salt showed conclusively that the mixture acted energetically upon the alkaloid. A substantial basis was thus afforded for the institution of experiments on animals. Had there been no reaction experiments would of course have been out of the question.

Experiment 1.—On June 2, 1½ mgs. of a solution of Merck's sulphate of veratrine was fed at 3.27 p. m. to a 63-ounce rabbit. No pronounced effect was noted up to 4.25, when 7 mgs. more was fed. The rabbit died from the effects of this dose in about one minute.

Experiment 2.—On the same day 7 mgs. of the same solution was fed to another rabbit, weighing 26 ounces. Death took place inside of two minutes.

Experiment 3.—On June 4, 7 mgs. of the same solution of veratrine sulphate was quickly mixed in a test tube with 3 c. c. of the permanganate solution noted above, and fed within four minutes to a large white rabbit. The weight of this animal was not ascertained, but it was not less than 2½ and was probably about 3 pounds. The permanganate solution, which has a deep-purple color, was added to the veratrine solution, a cubic centimeter at a time. In the first two instances the purple color was changed very rapidly, the resulting liquid presenting a straw-colored appearance, but the last cubic centimeter was not completely decolorized inside of a minute. No marked turbidity was produced. The whole of the mixture was then immediately fed, at 3.53 p. m., to the rabbit. The animal was carefully watched until 5 p. m., but appeared to remain in a perfectly normal condition. It was also in perfect health on the next day.

Experiment 4.—On June 14, 500 mgs. of an aqueous veratrine sulphate solution was poured, by means of a funnel and a rubber tube, directly into the stomach of a 50-pound sheep. This was followed almost immediately by 25 c. c. of a 1 per cent solution of permanganate of potash with a 1 per cent addition of aluminum sulphate, and the whole was washed down into the stomach with 100 or more cubic centimeters of pure well water. The time of administration, which was begun at 3.44 p. m., did not exceed two minutes. At 4.25 there was a slight indication of weakness in the hind legs, but the animal could walk as well as usual. This was the only symptom that was exhibited. When let out of the pen the next morning it grazed as heartily as ever.

ACONITE.

(*Aconitum columbianum* Nutt.)

An erect, smooth, single-stemmed plant 2 to 5 feet high, with a leafy base and a long terminal cluster of blue flowers. The divisions of the leaves are broader and less conspicuously separated from one another than in the species of larkspur. In Montana the plant grows in Gallatin and Park counties, near the Yellowstone Park and on Lolo Creek. The distribution of this plant in the United States outside of Montana includes South Dakota, Colorado, Wyoming, Idaho, Washington, Oregon, and California.

The different species of aconite are known to contain poisonous principles, probably more virulent than those contained in their nearest relatives—the larkspurs. Fortunately this species has an exceedingly limited distribution in Montana, being found, so far as known, only in the Bitter Root Mountains near Lolo and the Gallatin Range near the Yellowstone Park. Since the altitude of both of these places is high and the surrounding country not suitable for grazing, it is not likely that the plant will ever become of great importance in stock poisoning. Stockmen frequently speak of aconite poisoning, but all specimens of supposed aconite which we examined proved to be the tall larkspur.

PSORALEA.

(*Psoralea tenuiflora* Pursh.)

A slender, much-branched, hoary perennial, with digitately parted leaves, white or purplish flowers, and glandular pods. The plant resembles the lupines in general habit. This species grows on dry hills and plains at Great Falls, Billings, and Livingston. The plant has the peculiar and rather agreeable odor characteristic of the dried roots of another species of the same genus, *P. macrostachya*, which is used to some extent by the Indians of Mendocino County, Cal., as a fiber plant. Its general distribution is from Texas to Arizona, northward to the Missouri River and eastward to Illinois.

While botanizing at Livingston on May 30 attention was attracted to this plant on account of the close resemblance between it in its earlier or foliaceous stage of growth and the corresponding stage of *Malvastrum coccineum*. It grew plentifully on level pasture lands, and although at that time it was fairly succulent, it was left unmolested among closely cropped grass, thus suggesting the idea that it was probably poisonous. Upon chewing a small portion of a leaf that idea was made still more emphatic. The taste was not at all bad, and was even pleasant for a few minutes, but later the tongue was considerably benumbed, a sensation which lasted nearly two hours.

A quantity of the nonflowering plants 5 to 6 inches in height was collected for further investigation, and was preserved in a good turgid condition in a tin box until June 6. On June 3 an attempt was made to feed the plants to a rabbit, but the animal refused to eat more than four leaves, and as that quantity had no pronounced effect the preparation of an extract was deemed necessary. The basal portion of the stem, rather tough and fibrous, was rejected, but 36.5 grams of the fairly crisp growth was obtained, and, after thorough grinding in a sausage mill, was digested 1½ hours at blood heat with an equal weight of distilled water and then filtered through a linen bag, 47 c. c. of extract being obtained. For easy calculation, however, this was diluted up to 50 c. c. Seven centimeters of this extract, representing

5 grams of the green plant, was fed at 12.7 o'clock to a small rabbit weighing about 1½ pounds, and as no effect was noted up to 3.2 o'clock 14 c. c. more was administered. At 4.5 o'clock the rabbit was dejected and very uneasy, as was plainly evident from its labored respiration and its frightened actions, symptoms which were maintained until after 5.30 o'clock. At 9 o'clock the next morning the heart action and respiration were still exceedingly weak and rapid, the rate of the latter being over 150 a minute. The posterior part of the body was weak, being more or less decumbent. The animal was almost too weak to move its legs into a comfortable position after they had purposely been placed in an awkward way. It would not eat or drink even when coaxed. On June 8 the respiration and heart action had improved, and it began to eat with relish. On June 9 the appetite had greatly improved, so that observations were discontinued, although the functions of the heart and lungs had not yet become normal.

TALL CONE FLOWER.

(*Rudbeckia laciniata* L.)

This plant is known in Montana as wild sunflower and by other local names. The plant attains a height of from 2 to 7 feet, and is usually smooth, except for a slight roughness of the margins and upper surface of the leaves. The root leaves are divided into from 5 to 7 parts and those of the lower portion of the stem into 3 to 5 parts, while the uppermost leaves are 3-parted. The flower heads are from 2 to 3 inches across, with yellow drooping rays and a dull yellow disk. The plant grows in all parts of Montana in moist places, especially along the banks of streams and irrigating ditches.

In the summer of 1898 a farmer in the Gallatin Valley sheared his sheep, numbering about 100, during the first half of June. Soon after shearing, a season of cold rainy weather set in and the sheep sought shelter during that period. For two or three days they grazed exclusively in a small area of timber through which ran several streams. The tall cone flower was the most conspicuous plant in this area and stood about 2 feet high. During the time in question the sheep fed almost exclusively upon this plant. On the second day about 20 of the sheep showed symptoms of poisoning, and of this number 7 died. The symptoms were not observed by us and were very imperfectly described by the owner of the sheep. The sheep were at once driven away from this locality, with the result that no further case of poisoning occurred. No other plant which could possibly be suspected was to be found in the locality where the sheep were poisoned and appearances pointed strongly to this plant as the cause of the trouble. Specimens of the plant have also been sent to this Department from Missouri with the complaint that it is not infrequently fatal to hogs.

HENBANE.

(*Hyoscyamus niger* L.)

A coarse biennial 1 to 2 feet high, with wavy, clasping leaves and dull yellow, finely spotted flowers 1 to 2 inches in width, in long, one-sided leafy spikes (Pl. XX). This plant was found at Bigtimber, Mont., but no other locality is known in the State. It has also escaped from cultivation in Nova Scotia, Ontario, New York, and Michigan.

The henbane, or black henbane, is the most important and interesting representative of the potato family found in Montana. The order is very feebly represented on account of the high latitude, but this coarse, viscid plant, which is a native weed of Europe, has become well established in at least one station in the State. Herbarium specimens were collected at Bigtimber on May 12. Other specimens were collected at the same place on June 15. Stock generally shun the plant on account of its ill odor and harsh texture, but a few cases of poisoning by it are recorded in foreign literature. Inquiry at Bigtimber revealed the fact that the plant has there proved poisonous to chickens which ate the ripe seeds. Ripe seeds were collected in July and furnished to this Department by Mr. Roy Spillman. Since the henbane yields an abundance of seed, and since the plant has developed so robustly at Bigtimber, it is quite possible that it may spread to other localities, if it has not already done so. The plant is a deep-rooted perennial and requires vigorous pulling to eradicate it thoroughly.

Experiments with the permanganate mixture and hyoscyamine, the characteristic alkaloid of the henbane, seem to indicate that it would not serve well as an antidote in case of poisoning caused by the plant.

BLACK NIGHTSHADE.

(*Solanum nigrum* L.)

A smooth, much-branched annual, 4 to 12 inches high, with ovate, wavy toothed leaves, white flowers in small clusters on the sides of the stem, and black globular berries. The plant blossoms from June to August. This species is becoming common in cultivated and waste ground in all parts of Montana. It is common throughout the United States in similar situations. Very little, if any, damage is to be attributed to the plant in Montana. A few cases of poisoning are recorded against it elsewhere for calves, sheep, goats, and swine.

POTATO.

(*Solanum tuberosum* L.)

On a stock ranch in the Flathead Valley 6 pigs died from eating uncooked potatoes. The potatoes had all sprouted and were considered

BLACK HENBANE (HYOSCYAMUS NIGER).

of no value, except for feeding. As soon as it was found that they were poisonous in an uncooked condition, the owner of the pigs cooked some more potatoes in the same condition and fed them to other pigs without causing any poisoning. The symptoms of poisoning by this plant were a slowly progressing paralysis, which became complete after about twenty-four hours, an increased salivation, and a regurgitation of the stomach contents.

SPREADING NIGHTSHADE.

(*Solanum triflorum* Nutt.)

A smooth prostrate annual with rough, widely branching stems, 7 to 9 lobed leaves, numerous clusters of small white flowers in groups of three, and green berries a half inch in diameter. The appearance of the fruit has given the names wild potato and wild tomato to this plant. It grows in Madison, Gallatin, Park, and Cascade counties, as well as in other isolated localities, on cultivated ground and around prairie dog towns.

The spreading nightshade is native to the Great Plains, and is a common garden weed from Arizona to Texas, and through Montana to British America. A single complaint of the poisoning of cattle by the fruit was sent to this Department from Nebraska, and rabbits inoculated with the juice of the berries sent from that State were badly poisoned. Berries sent to us at Washington by Mr. W. W. Jones, of Bozeman, proved to be equally bitter, even after preserving in the form of a jam. No experiments were made with the berries or with extracts upon animals. In Montana, it is asserted, the fruit under the name of ground cherries is pickled with vinegar, and eaten either in that state or while still raw.

PLANTS SUSPECTED OF BEING POISONOUS.

PRAIRIE FENNELS.

(*Lomatium* and *Musineon* spp.)

Several species of Lomatium and one of Musineon grow quite abundantly on the dry open ranges, and some of these have, perhaps on account of their ill odor, been suspected by stockmen of poisoning sheep in the early spring. These plants are among the first to appear in the spring, and this circumstance, together with the umbels of yellow or white flowers and the general resemblance to other members of the parsley family, should serve to identify them in connection with the illustrations. We were unable to obtain any evidences in the field which would tend to establish the poisonous character of these plants. The only native species in these two genera which has thus far been proved to be poisonous to stock is *L. nudicaule* (Pursh) Coult. & Rose,

a plant native to Washington. Satisfactory evidence against this plant has been given by Prof. C. V. Piper and Mr. G. R. Vasey of the State of Washington. So far as known, however, this species does not occur in Montana. Several localities were examined where poisoning of sheep had occurred in the early spring, but in all of them other plants of known poisonous character, especially death camas, were found in abundance. Some of the species of Lomatium which grow in other States are known to be edible. It must, therefore, remain somewhat doubtful if any of the species which grow upon the ranges in Montana were concerned in the cases of sheep poisoning where they were suspected, and it appears probable, moreover, that one species, *Lomatium montanum* Coult. & Rose (Pl. XXI), could easily be improved by careful selection and cultivation sufficiently to serve as a staple vegetable.

On June 16 1½ c. c. of a 50-per-cent alcoholic extract of the leaves and stems of *Lomatium platycarpum* (Torr.) Coult. & Rose (Pl. XXII), representing 1.3 grams of the fresh leaves of nonflowering plants collected May 28, was injected hyperdermically into a 59-ounce rabbit without causing any apparent ill effect. Dr. S. B. Nelson has recorded[1] an experiment made by himself at Pullman, Washington, on a sheep, in which the animal ate 4 pounds of *Lomatium grayii* Coult. & Rose, a vile-smelling plant, without causing any noticeable ill effect. This species does not occur in Montana.

Musineon hookeri (Torr. & Gray) Nutt. (Pl. XXIII) is a plant of the same family and has been suspected by stockmen of being poisonous. On May 22 specimens of this plant growing on steep rocky hillside pastures east of Bozeman Creek were observed, the leaves of which had been closely cropped. The flowering stem, on the contrary, had in all of the several instances noted been untouched. This circumstance was at once explained by comparison of the taste of each. The leaves had a rather agreeable taste, like that of parsley, while the flower stem was disagreeably bitter. The parsley-like taste of the leaves, considered together with their parsley-like appearance, suggests that the plant might easily be mistaken for parsley. The finger-like subdivisions of the leaves of the latter and their curly edges suffice at once to distinguish them from the former, and, besides, parsley seldom, if ever, escapes from cultivation in Montana.

The plains Cymopterus (*Cymopterus acaulis* (Pursh) Rydberg) (Pl. XXIV) also belongs to the carrot family. According to observations made near Custer in 1890 by Dr. J. W. Blankinship, the Crow Indians hold that its semifleshy root is poisonous. No cases of stock poisoning from it have been reported. It has been suspected by some stockmen in Montana, being included by them in the general term "wild parsnip."

[1] U. S. Dept. Agr., B. A. I. Bul. 22, p. 14. 1898.

PRAIRIE FENNEL (LOMATIUM MONTANUM).

PRAIRIE FENNEL (LOMATIUM PLATYCARPUM).

PRAIRIE FENNEL (MUSINEON HOOKERI).

PLAINS CYMOPTERUS (CYMOPTERUS ACAULIS).

MOUNTAIN FALSE LUPINE (THERMOPSIS MONTANA).

FALSE LUPINE.

(*Thermopsis* spp.)

Erect perennial herbs 1 to 3 feet high, with trifoliate leaves and bright yellow flowers in terminal racemes (Pl. XXV). The two species are distinguished by the fact that in the first the pods are curved and pendulous, while in the second they are straight and erect, and by the further fact that the first species, which is the taller plant, is more abundant in dry places, while the second seems to prefer rich, moist meadows or the banks of streams. The difference in habitat, however, is not without its exception. The yellow pea (as it is commonly known in Montana) or prairie false lupine (*Thermopsis rhombifolia* (Nutt.) Richards) occurs along the Yellowstone Valley from the eastern border of Montana to Livingston, along the Missouri from its head waters to Fort Benton, and in Flathead, Missoula, Ravalli, Lewis and Clarke, Beaverhead, Gallatin, and Madison counties. The general distribution of these plants is from Colorado to New Mexico, north to Washington, and eastward to Nebraska and Dakota.

The yellow pea has a general distribution throughout Montana. It is especially abundant east of the Rocky Mountains, occurring from the lowest altitude up to 6,500 feet. In many places it covers the ground so completely over large areas as to form conspicuous patches of bright yellow at the time when the plant is in bloom. Mention has already been made of the fact that sheep were observed feeding upon the leaves of this plant without suffering any serious consequences. It was observed that a small number of pods were formed on this plant during the season of 1900. In some localities it was difficult to find a single pod on the plant. Considerable variation in the number of pods which mature is frequently observed in the case of a number of native species of the pea family.

On May 9 a serious case of poisoning occurred on a cattle ranch near Wibaux. About 150 cattle were affected with symptoms of poisoning, and of this number 100 died. A telegram was received from the owner of the cattle by Dr. M. E. Knowles, who requested one of us to visit the locality with him. Upon arriving at the place it was found that the animals had been dead for two days, and post-mortem examinations were, under the circumstances, practically valueless. One such examination was made with such unsatisfactory results that no further work of this sort was attempted. No definite statement could be obtained concerning the symptoms manifested by the animals before death. In this case, as in many others, malicious poisoning had been suspected, and it was suggested that the water had been poisoned. Only one dead animal was found near the water, and the others lay scattered about the plains at some distance from one another. The stomach of the one animal upon which a post-mortem examination was

made contained what appeared to be the leaf and pods of Thermopsis. The progress of decomposition was so far advanced that a positive identification of the stomach contents was impossible. All parts of this plant are comparatively soft, and therefore soon lose their identity in the stomach.

The range upon which these animals died was remarkably free from weeds and poisonous plants, with the single exception of *Thermopsis rhombifolia*. During a drive of 30 miles on this range no other plants were seen which had ever been suspected of being poisonous. But in the absence of clear postmortem evidence, and without even a knowledge of the symptoms, it is impossible to arrive at any positive conclusion regarding the case.

The seeds of the yellow pea are strongly suspected of causing the death of children near Winnipeg.

It can hardly be stated that the mountain false lupine (*Thermopsis montana* Nutt.) (Pl. XXV) is considered a poisonous plant in Montana; on the contrary, it is regarded by stockmen as good hay if cut young. Large quantities of the flowering plant, however, were observed to be left unmolested in stock yards where stock were standing and where there was no other verdure. This fact suggests very strongly that the flowering plant, at least, is not edible. It is barely possible, also, that a suspected plant described as being gray and growing near water at Logan is this species. It grows in very great abundance in wet creek bottoms near that place. It was said that this gray plant is especially poisonous after a rain storm.

A supply of the flowering plants was sent at my request from Toston on May 26, and arrived on the 27th, in a slightly wilted condition. The leaves regained their freshness, however, after they had been sprinkled and had lain in a moist piece of newspaper for a few hours. Fifty grams each of the flowering stems, exclusive of leaves, and of the leaves and stems, exclusive of flowers and the tough basal portion, were deprived of adhering moisture by the use of blotting paper, ground separately in a sausage mill, and each soaked for a day in 100 c. c. of water, after which they were heated a half hour at blood heat and then filtered. The taste of the ground leaves was very nauseating and much like that of green beans.

Experiment 1.—On May 31 10 c. c. of the water extract from the flowers, equivalent to 5 grams of the fresh material, was fed at 11.42 to a rabbit the weight of which was not ascertained. From 12 m. to 1.26 p. m. the symptoms noted were a slight malaise and drowsiness, with more or less labored, wheezy breathing. At 3.15 more of the extract was offered to the animal, but unfortunately it was accidentally killed in the attempt to feed it. The solution rapidly became moldy and was unfit for further experiments.

Experiment 2.—On June 1 10 c. c. of the leaf extract, equivalent to

SYNTHYRIS (SYNTHYRIS RUBRA).

5 grams of the fresh leaf, was fed at 2.53 p. m. to a 26-ounce rabbit. No marked symptoms were noted up to 5 o'clock. The rabbit was well and sound the next morning.

Experiment 3.—On June 5, 20 grams of the fully turgid leaves of plants collected on Middle Creek on June 3 was offered at 10.20 a. m. to a 1-pound rabbit. At 5.5 p. m. it was found that after making the proper deduction for evaporation, as determined from a check, the amount eaten was but little over 2.8 grams. No ill effect was observed. The rabbit was not hungry when the leaves were offered.

Experiment 4.—The residue from which the water extract of the flowers used in Experiment 1 was obtained remained soaking in 50 per cent alcohol until June 12, when it was evaporated down to 20 c. c. Half of this was fed at 2.10 p. m. on June 12 to a rabbit. It exhibited no acute symptoms during that day and on the following day it was perfectly well.

Experiment 5.—The residue from which the water extract of the leaves used in Experiment 2 was obtained was likewise soaked in 50 per cent alcohol for the same length of time and then filtered and evaporated down to 17 c. c. On June 16, 1½ c. c. of this solution, representing 4.4 grams of the fresh leaves, was injected hypodermically into a 25-ounce rabbit without causing any ill effect.

SYNTHYRIS.

(*Synthyris rubra Benth.*)

An erect simple-stemmed perennial, 3 to 18 inches high, with a thick rootstock, long-stemmed basal leaves and small stemless upper leaves, and small purplish pink flowers in a dense leafy terminal spike, blossoming in earliest spring (Pl. XXVI). This plant grows on hills and mountain sides throughout the State. The general distribution of the species extends from Montana to Utah and westward to Oregon and Washington.

The species is common in loose soil and in turf up to an altitude of about 7,500 feet near Bozeman. On May 28 it was found in flower at an altitude of about 7,000 feet on Bridger Peak, where specimens were collected for investigation and for the photograph here reproduced. At lower altitudes it had already passed out of bloom.

Fifty grams of the whole plant exclusive of the root was ground up while still fresh in a sausage mill and soaked for a day with 100 c. c. of distilled water, after which it was warmed at blood heat for a half hour and then filtered, the residue being put to soak with 100 c. c. of 50 per cent alcohol.

Experiment 1.—Ten cubic centimeters of the water extract, equivalent to 5 grams of the fresh plant, was fed at 11.19 a. m. to a 33-ounce

white rabbit. Only a slight uneasiness was noticeable up to about 1 o'clock, when this feature became strongly marked and was accompanied with rather heavy breathing. During most of the time from 1.13 to 2.57 it remained quiet and was very sleepy. At 2.57, 15 c. c. more of the extract was given. At 3.30 the drowsiness was strongly marked, and at the same time the heart's action was tumultuous, the thumping being very conspicuous. At 3.40 there was a curious lateral movement of the jaws; the ears and the skin were cold, and the heart still rapid. At 3.55 there was much restlessness, but at 4.5 the rabbit was so much easier that it would eat well. At 7.55 32 c. c. more of the extract was administered by mouth in the same way as before, and on the next morning the rabbit was found dead.

Experiment 2.—A second experiment was begun with the same water extract on June 6, but in the attempt to feed an ounce to a rabbit it died, and as there was not then a sufficient amount of the extract left, no other experiments were made with the same solution.

Experiment 3.—A stable horse to which some of the fresh leaves were offered while in the field would not touch them, although strongly persuaded to do so.

Experiment 4.—On June 11 fresh material from fruiting plants, the leaves of which had a decidedly bitter taste, was collected on Bridger Peak and a water extract was made of it on the same day. On June 14, 200 c. c. of this extract, the equivalent of 155 grams of leaves, was fed at 1.15 p. m. to a sheep weighing about 50 pounds, the liquid being poured into the stomach by means of a funnel and rubber tube, as explained in the introduction. Up to 3 p. m. no particular uneasiness had been noted, and so the remainder of the extract, the equivalent of 176 grams of the fresh leaves, was given in the same way. At 3.25 a slight giddiness was noted, which was accompanied with heavy breathing, a disinclination to move, and a weaker heart action. The animal remained uneasy during the remainder of the day up to 7.15 o'clock, but on the next morning it fed heartily and was about as well as usual.

Experiment 5.—The residue from which the water extract used in Experiment 1 was prepared remained in contact with some 50 per cent alcohol until June 16, when it was filtered and the filtrate evaporated down to 25 c. c. One and one-half cubic centimeters of this, equivalent to about 3 grams of the fresh leaves, was injected hypodermically into a 48-ounce rabbit, but no ill consequence was noted.

In an experiment made by Dr. S. B. Nelson[1] with the same plant at Pullman, Washington, a sheep ate a pound of the plant within a period of twenty-four hours without experiencing any ill effect.

[1] U. S. Dept. Agr. B. A. I. Bul. 22, p. 14. 1898.

WESTERN WILD CHERRY (PRUNUS DEMISSA).

WESTERN WILD CHERRY.

(*Prunus demissa* (Nutt.) Walp.)

A shrub or small tree, greatest height about 30 feet and diameter 1½ feet, with rather thick, acute leaves, white flowers in terminal dense racemes, and dark purple or black, rather sweet, edible fruit. (Pl. XXVII.) This species is rather common in valleys and canyons in all parts of the State. The general distribution of the Western wild cherry extends from the Dakotas to Nebraska and New Mexico, and west to California.

The first wild cherry blossoms of the season were observed at Logan, Montana, on May 17. The bush is most plentiful along the creeks, but grows at the base of rocky ledges and in association with juniper among granite bowlders in the mountains. A few bushes were noted at Logan the crisp, leafy ends of which had been slightly browsed, and as cattle were grazing in the immediate vicinity it is to be presumed that they ate them. Stock do not often eat cherry leaves, though they eat them occasionally; but no cases are on record where stock have been poisoned by eating the leaves of any species while still on the tree. It is only after they have been cut off and have partially wilted that they are considered dangerous, the reason for this being that during the process of wilting prussic acid is formed from nonpoisonous constituents which are always present in the living leaf. This is known to be true of wild black cherry (*P. serotina*), choke cherry (*P. virginiana*), and wild red cherry (*P. pennsylvanica*), and is probably true of the present species, which resembles *P. serotina*, the most poisonous species, more closely than it does any other species. The wilted leaves have the characteristic odor of prussic acid.

Forty-three grams of crisp leafy shoots, collected May 14 and preserved unwilted in a tin box, were carefully rubbed up in a mortar with 200 c. c. of water three hours later, and allowed to stand until the next morning when it was filtered. This extract had the characteristic odor of prussic acid. One cubic centimeter, representing less than a half gram of the fresh leaf, was then injected hypodermically into a young rabbit, but it was without effect. The extract was too dilute to show the characteristic effects. Had a stronger extract been made from leaves more thoroughly shredded, it would undoubtedly have given the characteristic tests for prussic acid.

BANEBERRY.

(*Actaea eburnea* Rydberg.)

A smooth perennial, 1 to 2 feet high, with compound leaves repeatedly divided and an elongated raceme. The small white flowers, which

bloom in May and June, later produce white ellipsoidal berries containing about 12 seeds. (Pl. XXVIII.) The plant is generally distributed in the State in moist, shady places. It very closely resembles the plant known to botanists as *Actaea arguta*, which has commonly been mistaken for it, but which may at once be distinguished, when in fruit, by its red berries. *A. rubra*, which also has red berries, is native east of the State.

No cases of stock poisoning have been reported against this plant, and indeed few cases are reported against the similar species which are abundant both in the Eastern States and in Europe. Sheep are, however, said to be poisoned in Europe by eating the white baneberry (*A. spicata*). The berry is probably the most poisonous part, exclusive of the root.

Experiments.—Two weighed portions of the fresh flowering plants, exclusive of the flowering heads, were macerated in a mortar with definite amounts, respectively, of water and of 50 per cent alcohol, both being added by small portions successively. The water extract became moldy before it could be used, and was therefore discarded. The alcoholic extracts were placed together with the macerated fiber and allowed to stand from May 14 to May 25. Forty-four grams of the fresh plant were thus extracted with 200 c. c. of alcohol. The alcohol from half of this extract was then driven off at the temperature of boiling water. To the residue, which was sirupy and ill smelling, 50 c. c. of distilled water and 25 c. c. of 95 per cent alcohol was added to bring it fully into solution again. Fifteen cubic centimeters of this, an amount representing $4\frac{2}{5}$ grams of the fresh plant, was then fed with a stomach tube and syringe to a rabbit weighing 28 ounces. For checking the effect of the alcohol, the same quantity was fed in the same dilution to another rabbit having approximately the same weight; but although both were strongly affected no pronounced differences were noted in the symptoms. It is quite possible, of course, that any toxic effect that might have had a tendency to show itself was counteracted by the comparatively large amount of alcohol contained in the extract. A larger dose was not given because it was thought inadvisable to give a larger dose of the alcohol. The sirupy extract could not, unfortunately, be completely dissolved in water, and could not on this account be very easily administered to rabbits. On theoretic grounds and from the odor and taste we believe that it would prove poisonous. The after taste of the leaves, a few of which were chewed, was anything but agreeable, being very bitter and nauseating, although at first no bad taste was apparent. After drinking water, a sweet taste was noted fifteen to thirty minutes subsequent to chewing the leaves.

BANEBERRY (ACTAEA EBURNEA).

OAT SMUT.

(*Ustilago avenae* (Pers.) Jensen.)

It frequently happens that where seed oats are untreated the smut develops to such an extent that the crop is worthless for grain. Usually, however, the crop is harvested at the regular season and thrashed for the small quantity of grain which is present. In a case of this sort which occurred in the Gallatin Valley during the summer of 1898 the crop of oats appeared so badly infested with smut that it was cut before becoming matured and stored for hay. During the following winter a herd of dairy cows belonging to the owner of the hay were fed upon clover and timothy hay until late in winter, when orders were given to begin feeding the smutty oat hay. Within twelve hours after the first feed one-half of the dairy cows died with symptoms of gastritis and cerebral excitement. No more of this hay was fed and no further loss of dairy cows was suffered. On post-mortem examination it was found that the walls of the stomach were much congested, showing a decided irritation. On examination of the oat hay it appeared that the oat heads were almost a solid mass of smut, having been cut before the smut had blown away. The evidence against the oat smut as being the cause of the death of these animals is considered very strong.

SPURGES.

(*Euphorbia* spp.)

Erect, spreading, or prostrate herbs, with milky, acrid juice, and opposite or alternate leaves, the upper in whorls and frequently colored at the tops.

All of the numerous spurges native to the United States contain an acrid, milky juice which is poisonous, but stock very rarely eat the plants, as almost all are rather inconspicuous and would offer but little attraction, even if they were not repulsive to the taste. Stock have, however, been poisoned by drinking the water into which the leaves had been thrown. Six species are accredited to Montana, but none have been suspected of being poisonous to stock. They seldom grow at an altitude higher than 6,000 feet, and are common, as a rule, only in the lower plains region.

Euphorbia glyptosperma Engelm., which is probably the most abundantly distributed species, is a troublesome garden weed near Custer, Mont. It is a smooth plant, with linear-oblong, sharply serrate leaves. Its flowers are in leafy clusters on the side of the stem. *Euphorbia marginata* Pursh, the juice of which is used to some extent in Texas to brand cattle, and which has once been suspected of being poisonous to cattle, grows on prairie pastures up to about 3,000 feet in Custer,

Dawson, and Valley counties and in the Yellowstone Valley. It is a smooth, erect plant, 2 to 3 feet high, with ovate leaves, the uppermost of which have petal-like margins. The seeds of this plant have proved nearly fatal to children who ate a few of them, and the juice is well known to be poisonous to the skin of many persons, the effect being somewhat like that caused by the oil of the ordinary poison ivy (*Rhus radicans*) of the eastern United States.

FIELD HORSETAIL.

(*Equisetum arvense* L.)

A rush-like, branching plant, with jointed stems from running root-stocks, having sheaths at the joints and, when fertile, terminated by a conical, spike-like fructification composed of shield-shaped, stalked scales. The fertile stems are from 4 to 10 inches high, the sheaths 8 to 12 toothed. The sterile stems are slender and produce long, much-branched, quadrangular branches. This plant occurs everywhere in moist places across the continent, but is more abundant in the eastern part of the country.

A case of the poisoning of horses by eating the field horsetail was reported to the United States Department of Agriculture from Connecticut in 1871, and one of horses and sheep from Vermont in 1899 and also in 1900. Cases are not, however, at all common in the United States and the plant has not been laid under suspicion at all in Montana. It grows very commonly around Bozeman.

Fifty grams of the more foliaceous male plants was gathered on June 6 and fed at 11 o'clock the same morning to a small rabbit weighing somewhat less than a pound, which had been deprived of its breakfast. It ate the plant readily and with apparent relish, all of it having disappeared within four hours. The only symptom of distress noted during the whole day was a decided thirst, which was made evident especially at 3 o'clock when, after voiding a copious amount of urine, the animal turned around and lapped it up again. The water then offered was consumed in unusual quantity. On the next morning a peculiar action of the jaws was noted, which seemed to indicate that the mouth had been made sore by eating the harsh leaves. Inspection of the mouth, however, showed no apparent abrasion. The rabbit was otherwise perfectly well, and at 2 p. m. it readily ate some fresh plants which were offered. Had the feeding been continued daily as a nearly exclusive diet some harm, and possibly fatal results, might have followed; for the experiments made in Europe show that a very similar species (*E. palustre*) is fatal to horses when hay contaminated with it is fed to them in considerable quantity. The plant, if deleterious, is evidently so only on account of its harsh scouring action in the mouth and intestinal tract. Meadow hay containing a large amount of field horsetail should be fed sparingly.

SNEEZEWEED.

(*Helenium montanum* Nutt.)

A smooth, angular, branching perennial 1 to 3 feet high, with lance-shaped leaves and numerous conspicuous yellow flowers, which appear in autumn. The plant is commonly called sunflower or wild sunflower in Montana. This species occurs abundantly in moist grounds in Gallatin, Lewis and Clarke, Madison, Cascade, Choteau, and Missoula counties. Its general distribution is from Mississippi and Texas to Nebraska, Saskatchewan, and Montana. The closely related Eastern species, *H. autumnale* L., is known to be poisonous to stock, but no cases have been reported against *H. montanum* from the State.

OREGON YEW.

(*Taxus brevifolia* Nutt.)

A tree with leaves resembling those of the red fir. The fertile cones are represented by a single ovule, surrounded by a red, thickened disk, which becomes fleshy and berry-like. This species is found sparingly in Montana, west of the Rocky Mountains, at Columbia Falls, Kalispell, Bearmouth, and Lolo.

The leaves would probably prove fatal if eaten by stock, but inasmuch as the tree grows in very inaccessible places, there is little danger to be apprehended from it. The leaves and seeds of the European yew (*T. baccata* L.) are well known to be poisonous.

EAGLE FERN.

(*Pteris aquilina* L.)

The common eagle or bracken fern has a stout, woody rootstock and large leaves, 2 to 4 feet long by 1 to 3 feet wide, which are 3-divided, each branch being pinnately compound. It occurs in woodland at Summit, Columbia Falls, Libby, Kalispell, and Missoula, and in the Bitter Root and Deerlodge valleys. The distribution of this plant includes nearly all of North America.

Cases of poisoning of horses and cattle by this plant have been reported from England and from a few localities in the United States. No complaint against it has been sent in to the Department of Agriculture from Montana.

ARNICA.

(*Arnica monocephala* (L.) Olin.)

Other names: Mountain tobacco; Arctic leopard's bane; Arctic arnica.

An erect, simple, branching perennial 1 to 2 feet high, with opposite leaves and long-stemmed heads of yellow flowers from 1 to 2 inches

in diameter (Pl. XXIX). The leaves are narrowly oblong or lance-shaped, thickish, the upper ones linear. The plant grows in all parts of Montana in woodland and moderately moist localities. This species is common throughout the Rocky Mountain region.

This plant, most commonly known as arnica, is one of the most common flowers in pasture lands in and about Bozeman in May and in the early part of June. It has an odor and taste much like that of the official drug, and, in fact, an extract made from the heads is considerably used locally as a liniment. No specific cases of poisoning caused by the plant have been reported from Montana, and we are not aware that it is eaten, but it has, nevertheless, been suspected of being poisonous to stock.

Dr. S. B. Nelson[1] states that a sheep ate 2 pounds (of the leaves?) of *A. fulgens* within a day without experiencing any bad effect. The plants had been gathered eighteen hours.

ANEMONE.

(*Pulsatilla hirsutissima* (Pursh) Britton.)

A silky perennial 3 to 10 inches high, with an erect purplish flower developed before the leaves, its parts numbering from 5 to 7, the leaves 3-parted with the parts further subdivided. The flowers are from 2 to 3 inches in diameter when fully opened, and the seeds in the fruiting heads bear long silky tails. The flowers appear in earliest spring. This plant is one of the most common spring flowers on hillsides in all parts of the State. Its general distribution is from the Rocky Mountains eastward to Illinois and Wisconsin.

Specimens were found in blossom at middle elevations on Bridger Peak as late as May 26. The taste of the plant is acrid, and it has been suspected of being poisonous by stockmen, but no cases have been brought to our attention in which good evidence could be obtained against the plant.

RED WIND FLOWER.

(*Anemone globosa* Nutt.)

Perennial silky herbs 6 to 12 inches high with 2 to 3 parted leaves, their divisions linear, and with white, greenish, or red flowers, followed by an oblong, silky, fruiting head. The flowers appear in May or June. The plant is common in valleys and open woodlands throughout the State. The general distribution of the plant includes the northern borders of the United States and northward across the continent, and also the Rocky Mountain region through Colorado. The stem has a very acrid taste, and would undoubtedly prove poisonous if eaten. No instances of poisoning are known, and no evidence has been adduced to show that stock have eaten the plant.

[1] U. S. Dept. Agr., B. A. I. Bul. 22, p. 13. 1898.

ARNICA (ARNICA MONOCEPHALA).

DOGBANE.

(*Apocynum* spp.)

Pale smooth perennials, 1 to 5 feet high, with tough fiber, opposite sharp-pointed leaves, small white or rose-colored flowers in terminal clusters, and pods 2 to 7 inches long. Two species of dogbane grow in Montana, both flowering in similar situations from May to June. Their preferred habitat is in waste places, along public highways, and on banks. The two species seldom grow together. They may be distinguished by the rose-colored flowers of the one species and by the greenish white flowers of the other. Both species are generally distributed across the continent. Dr. J. W. Blankinship states that *Apocynum androsaemifolium* L. is very common on dry hillsides in Montana. On June 11 the crisp, reddish brown plants of this species were but 3 to 5 inches high, but they were abundantly supplied with an acrid milky juice. On Juue 17, at lower elevations eastward, the plants were seen in railroad excavations in a much more advanced stage of growth. This plant, as well as *A. cannabinum* L., is poisonous. Both have tough stems and are not therefore enticing to stock, especially since wholesome vegetation is abundant at the season when they are in a crisp and succulent condition. Both have, however, been suspected by stockmen of being poisonous. The dried plants are not so poisonous as the fresh ones.

SHOWY FRASERA.

(*Frasera speciosa* Dougl.)

A large, stout leafy herb 2 to 5 feet high, with a single erect stem from a thick bitter root and numerous greenish white, dark-dotted flowers in a long leafy cluster. The root leaves are from 6 to 10 inches long, and the stem leaves are arranged in whorls of 4 to 6. The plant is found in Montana on dry hillsides in the Judith Basin and on the Belt, Bridger, Absaroka, Rocky, and Bitter Root mountains. The general distribution is from Wyoming to Oregon and southward to New Mexico and California.

Four plants 6 inches in height and without any sign of a flowering stalk, were collected in Rocky Canyon on May 26 by Dr. J. W. Blankinship and delivered at the laboratory in a fresh condition on May 28. Thirty-one grams were roughly torn into small pieces and rubbed up vigorously in a mortar with 50 c. c. of water. The water extract was lost, but the residue was allowed to soak in 50 c. c. of 50 per cent alcohol from May 29 to June 16, when the filtrate therefrom was given hypodermically to a healthy young rabbit. Previous to this the solution had been evaporated on a water bath down to 7 c. c., most of the alcohol being thus expelled. One and one-half cubic centimeters of

this evaporated extract, representing 4.4 grams of the fresh plant, was injected under the skin of a 41½ ounce rabbit without causing any marked symptoms. No further opportunity for securing a supply of the plants was offered. The species is abundant in the Yellowstone Park.

A similar species, *F. albicaulis*, which grows in the State of Washington, was fed by Dr. S. B. Nelson[1] to a sheep without causing any noticeably bad effects. In all 7¼ pounds was given in the course of five days, but no more than about 2½ pounds was eaten within any twelve hours of that period.

SNOWBERRY.

(*Symphoricarpos occidentalis* Hook.)

A low-branching erect shrub from 2 to 4 feet high, with small entire leaves and small white or pinkish flowers which are densely covered with long silky hairs. The plant blossoms in June. This shrub, called "buck brush" in many parts of the State, is known to be a good honey-producing plant. Snowberry grows abundantly in nearly all parts of the State, being especially abundant in the neighborhood of Flathead Lake, where it is occasionally grazed upon by cattle and horses. The general distribution of this species is from the mountains of Colorado to Montana and eastward. As a rule, however, the leaves of the snowberry are objectionable to stock and are rarely eaten by them. The berries have, according to Irvin Cockrell, been suspected of poisoning stock in winter.

The taste of the leaves taken directly from the bush on June 6 was not bad at first, but on prolonged chewing became disagreeably bitter. Six rabbits refused to touch the leaves, but the seventh, which was quite hungry, did venture to eat 1½ leaves. It would not eat more. No bad effect followed. The data in hand are not sufficient to condemn the shrub.

SLENDER NETTLE.

(*Urtica gracilis* Ait.)

A smooth-stemmed perennial from 1 to 4 feet high, with stinging hairs, lance-shaped leaves, and loose clusters of small greenish flowers, which blossom in June and July. This species grows in Montana in waste places in Gallatin, Meagher, Park, Madison, Lewis and Clarke, Cascade, Flathead, and Missoula counties. The general distribution of the plant includes the Rocky Mountains from California northward and thence eastward across the country.

The slender nettle is abundant in waste land and along creeks near Bozeman, but is not looked upon as in any way objectionable to stock.

[1] U. S. Dept. Agr., B. A. I. Bul. 22, p. 13. 1898.

Hundreds of acres of reclaimed swamp land in Michigan and Wisconsin have, however, been made worthless by the dense growth, horses refusing to pass through it to cultivate the soil. The stinging hairs of a closely related species, *U. holosericea* were the cause of the death of several horses in California in April, 1900.

LYGODESMIA.

(*Lygodesmia juncea* Don.)

A smooth erect perennial, 4 to 12 inches high, with rush-like rigid, much-branched stems, linear or scale-like leaves, and scattered heads of pink or rose colored flowers. This species, sometimes known as prairie pink, grows abundantly on dry prairies and plains in Park, Sweet Grass, Gallatin, Meagher, Lewis and Clarke, Choteau, and Teton counties. The general distribution of the plant is from Minnesota to New Mexico and Nevada. It has been suspected by stockmen both in Montana and Utah of being poisonous to stock. The plant was not investigated, but it was ascertained that the milky orange-colored juice of nonflowering plants gathered at Toston was extremely bitter and disagreeable to the taste.

BLACK GREASEWOOD.

(*Sarcobatus vermiculatus* (Hook.) Torr.)

A rigid, much-branched, erect, and scraggy shrub, 2 to 8 feet high, with linear leaves and smooth white bark upon the branches. This plant is found in alkaline soil near the head waters of the Missouri and Yellowstone, at Great Falls, and along Belt Creek. It is distributed from western Nebraska to Wyoming and Nevada and to New Mexico.

This plant grows in strongly alkaline soil, and is as a rule abundant wherever it occurs. No complaint of the plant being deleterious to stock in any way has been sent in to the Department of Agriculture from Montana. A correspondent in New Mexico states, however, that on one occasion he counted as many as 1,000 sheep that had been killed by eating the leaves of this plant. He claimed that cows are not affected by eating it at any time and that sheep can eat it freely in winter. Fatalities caused by eating the plant may perhaps be due more to the bloating effect than to any poisonous substances which the plant contains.

ERIOGONUM.

(*Eriogonum* spp.)

Plants with acid juice, alternate entire leaves, stems from 3 to 10 inches high, and small, delicate flowers of a white or yellow color.

One of the most common species, *E. flavum* Nutt., yellow eriogonum, is woolly throughout and has yellow, silky flowers, which blossom from May to July (Pl. XXX). These plants are found everywhere throughout the State on dry ranges, especially in poor soil.

On June 11 the yellow eriogonum, with scanty foliage, was observed in bud at an altitude of about 7,000 feet on Bridger Peak. It was not at all plentiful and there was an abundance of good pasturage at hand. An investigation of the plant was deemed much less important than of several others which had been suspected more strongly, and no experiments were attempted. Dr. S. B. Nelson[1] fed 3½ pounds of *E. heracleoides* to a sheep within one day without any ill effect.

SCARLET GAURA.

(*Gaura coccinea* Pursh.)

A nearly smooth herb, 6 to 12 inches high, with numerous narrow leaves and rose-colored or scarlet flowers in simple spikes (Pl. XXXI). The plant is common throughout the State on dry plains, blooming in May and June. The general distribution of this species is from Montana to Colorado and eastward to Arkansas.

Experiment 1.—On June 3, 32 grams of this plant collected at Livingston, May 30, about a week before the flowering time, was offered, still fresh, to a 1¼-pound rabbit. The whole quantity was eaten up clean within five hours, but no ill effect was subsequently noted.

Experiment 2.—On June 4 50 grams of the plants collected at Bozeman in the same stage of growth as before was fed within an hour after gathering to the above rabbit. In this case the herbage was eaten very slowly and without relish. A check experiment showed that three and a half hours afterwards only 20 grams had been consumed. There were no ill consequences.

Experiment 3.—On June 9 25 grams of rather succulent leaves from nonflowering plants nearly in bloom were eaten by a ¾-pound rabbit. The same animal had eaten a small amount of lupine leaves and seemed to be unwell prior to both experiments. It showed no additional symptoms of uneasiness after eating the leaves.

Experiment 4.—On June 10 a stable horse entirely refused to eat the plant either in the flowering or nonflowering stage.

TOWNSENDIA.

(*Townsendia parryi* D. C. Eaton.)

A low, erect, several-stemmed perennial, 2 to 6 inches high, with hairy stems, small stemless leaves having entire margins, and large

[1] U. S. Dept. Agr., B. A. I. Bul. 22, p. 14. 1898.

YELLOW ERIOGONUM (ERIOGONUM FLAVUM).

SCARLET GAURA (GAURA COCCINEA).

PINK-FLOWERED WILD ONION (ALLIUM BREVISTYLUM).

showy blue or white flowers, which appear in early spring. It is common on dry hillsides up to an altitude of about 8,000 feet.

It is one of the many plants which, perhaps, on account of its bitter taste, has been suspected in Montana of killing stock. No concrete cases have been reported to the Department against it. The fresh leaves from flowering plants gathered June 9 tasted a little like sunflower seed when first chewed, but after a minute or two it became bitter and disagreeable. Rabbits refused to eat the leaves when fresh. An inspection of plants in the field revealed but one or two which showed signs of having been grazed upon.

EDIBLE PLANTS WHICH HAVE BEEN SUSPECTED OF BEING POISONOUS.

WILD ONION.

(*Allium* spp.)

Strong-scented stemless herbs with linear leaves and a flowering stalk rising from a coated bulb. The plants attain the height of from 3 to 20 inches, and the flowers are borne in flat-topped clusters. The odor of the plant and the shape of the flowering cluster should at once distinguish it from death camas, with which it seems to have been confused by some stockmen. The species of wild onion are generally distributed throughout Montana and grow in much drier situations than does the death camas. The taste of the pink-flowered wild onion (*A. brevistylum* S. Wats.) (Pl. XXXII) does not differ materially from that of the ordinary onion, but may perhaps be somewhat stronger. It is claimed to be more pungent than the white-flowered species (*A. reticulatum* Fraser), which grows in great abundance in open grassy fields and which has a larger bulb.

The white-flowered wild onion was in blossom on May 23 on the slope leading up to the bench land from the east side of Bozeman Creek. On June 11 the pink-flowered species was in bloom on the north slope of Bridger Peak at an altitude of about 6,000 feet. For a number of years complaints had been made of the poisonous action of wild onion, which was suspected of causing the death of sheep in a number of instances. We were unable, however, to obtain any evidence against any of the species, and could not understand why the plant should be suspected. But during the present season it was found that a considerable number of stockmen applied the name wild onion to death camas without distinguishing between the two species. Apparently this confusion of names accounts for the suspicion that has attached to the wild onion. It is not believed that the species of wild onion have any injurious effect upon animals except to taint the meat and the milk with a disagreeable flavor. A few residents of

Montana claim that, while the white-flowered wild onion is not poisonous, the pink-flowered is so, an idea which may be due to the fact that the latter species is not nearly so well known as the white, and is more easily confused with poison camas, which has a somewhat similar bulb. One of our assistants, indeed, ate a considerable portion of a poison camas bulb before he was convinced that it was not an onion.

At 2 p. m., June 12, a Belgian hare, which had his food withheld since the preceding night, received 50 grams of the whole flowering plant of *A. brevistylum*. This was eaten somewhat gingerly, but at 8 o'clock, applying the correction for loss of weight due to evaporation of water, it was found that 48½ grams, nearly the whole amount, had been eaten. No ill effect was noted, and the same rabbit readily ate a few grams of the fresh onion the next day.

WILD LICORICE.

(*Glycyrrhiza lepidota* Pursh.)

An erect perennial half-woody herb, 1 to 4 feet high, with a thick, sweet root, slightly hairy pinnate leaves, yellowish-white flowers in dense spikes on the sides of the stem, and pods thickly covered with hooked prickles. The plant is generally distributed throughout the State along river banks and in moist, shady places. During the season of 1900 it was observed in abundance in Cascade, Flathead, Choteau, Lewis and Clarke, Meagher, Gallatin, Missoula, and Park counties. The general distribution is from Montana to New Mexico and westward to Nevada and California. The plant is quite commonly known to stockmen of the State by the name of licorice. The pods frequently become entangled in the wool of sheep and the hair of cattle. The leaves and stems of the wild licorice are freely eaten by cattle and horses on the range, but not by sheep so far as commonly observed. In many localities it grows so abundantly that stockmen have cut it for hay. Obviously the crop must be cut before the burs are formed, since these structures would render it almost impossible for stock to eat the hay. A few inquiries have been received in regard to the possible poisonous nature of the plant. There seems to be no reason for suspecting it, since large quantities of wild licorice have been eaten as hay, and direct feeding experiments with sheep and calves indicate that the plant is entirely harmless.

On June 3, 68 grams of the crisper upper portion of nonflowering plants collected along the banks of the Yellowstone and Livingston on May 30 was offered in a good turgid condition to a hungry rabbit. It was thought that the disagreeably bitter and astringent taste of the plant would cause the rabbit to shun it, but five hours afterwards it was found that about 18 grams had been eaten. No marked symptoms were presented, and the animal was in good condition the next day.

WILD HYACINTH (LEUCOCRINUM MONTANUM).

WILD HYACINTH.

(*Leucocrinum montanum* Nutt.)

A low stemless perennial, with a tuft of rather thick linear leaves, thick tuberous roots, and 4 to 8 pure white fragrant flowers, with a slender tube 1 to 2 inches long, which rises from below the surface of the ground (Pl. XXXIII). The flowers appear in early spring. The plant grows abundantly in dry, gravelly soil in the Yellowstone Valley, Judith Basin, and Gallatin Valley near Belgrade. It is found plentifully from Livingston to Big Timber, and especially north of these points to the Musselshell River. Outside of Montana the plant grows from Montana to Northern California.

It is supposed in Montana that this plant is poisonous to sheep after the fruit has been developed. No authentic cases have been investigated, and since the seed capsules are underground it appears very doubtful if they are ever eaten by stock. The plant blossoms early in May and the leaves dry up generally before the last of May. The roots consist of semi-fleshy fibers which can not be readily pulled up. Dr. Blankinship, who in 1890 made an investigation of the plants used by the Crows, stated that this tribe of Indians ate the roots. The taste of partially dried herbarium specimens is rather agreeable. No definite evidence whatever could be obtained which would connect this plant with any case of stock poisoning.

COW PARSNIP.

(*Heracleum lanatum* Michx.)

A coarse, strong-scented, woolly perennial 4 to 9 feet high, with decompound leaves and somewhat heart-shaped leaflets. Flowers white, in large flat-topped clusters. This plant is sometimes called wild parsnip, but may be readily distinguished from that plant by its much greater size and coarser character. It is common in situations similar to that in which the poison hemlock grows. In 1900 it was found in Gallatin, Park, Carbon, Sweet Grass, Meagher, Choteau, Cascade, Teton, Flathead, Lewis and Clarke, and Missoula counties. The general distribution of this species is from Colorado to British America and to the Atlantic; also in California.

The plant was first observed to be well in bloom at Bozeman on June 26. It is especially abundant and luxuriant in level swampy land among willows, but it grows well among shrubbery along creeks everywhere throughout Montana. Fifty grams of the succulent leafy nonflowering tops, collected on June 6, was fed on the same morning to a small yellow rabbit weighing about 1¼ pounds. All of this amount was readily eaten with the exception of a small part of a leaf, which finally became very badly wilted, and a fragment of a flower cluster

which was in bud. The succulent stem was especially well liked. At the end of seven hours it was calculated that 36 grams had been eaten. No bad results followed, but the animal was at times a little more drowsy than several others were. It was in good condition on the following morning.

The succulent stem of this plant is greatly relished before flowering time by the Indians of Round Valley, California. Before eating it, however, the more pungent skin is removed. The taste is then agreeably aromatic.

FALSE MALLOW.

(*Malvastrum coccineum* A. Gray.)

A tufted hoary perennial, 2 to 8 inches high, with numerous 5-parted leaves and racemes of showy brick-red flowers, which blossom in May and June (Pl. VI). This plant is very abundant on dry prairies, especially on poor soil, near Craig, Augusta, Choteau, Great Falls, Fort Benton, Utica, Lewiston, Martinsdale, Helena, Bozeman, and Livingston. The species grows on plains from Colorado to British America and eastward to Iowa and Minnesota.

The plant is not well in blossom near Bozeman until after the first of June. It is extremely abundant on some dry hillside pastures which are much used for grazing sheep, where, before flowering, the leaves may easily be mistaken for those of the purple larkspur. The latter, however, may at once be distinguished by the absence of stellate hairs.

The plant was at one time suspected in another State of being the cause of a certain case of poisoning, but the accusation was afterwards retracted, although the cause of death was never established. The leaves have no bad taste, but they are so densely covered with minute star-shaped clusters of rather rigid hairs that it seems possible that they might cause some physical ill effect on the digestive tract. The hairs are not without effect on the tongue when the leaves are chewed, and the fresh nonflowering plants were wholly rejected by a stable horse, to which they were offered. As a matter of fact, however, the plant, although it does not appear attractive as forage, is eaten extensively by sheep in several parts of the State. On a sheep range near Craig there are large areas which are occupied exclusively by the false mallow. It was noticed that sheep had a decided liking for the plant, and grazed upon such areas as long as any of this plant could be found. Similar conditions were observed in other parts of the State. A number of sheep raisers have noticed sheep eating this plant, and have, in one or two instances, suspected it of being poisonous. These suspicions are probably unfounded, since, as already indicated, the plant is eaten extensively by sheep in some localities without untoward results.

SAGEBRUSH.

(*Artemisia* spp.)

Bitter aromatic herbs or shrubs, with narrrow alternate leaves and small yellowish or greenish flowers in terminal clusters. The species are somewhat hairy throughout. About 20 species of sagebrush grow in different parts of Montana, and some of them are recognized by stockmen as valuable forage plants for the late fall and winter grazing.

Various species are suspected in Montana of being poisonous to stock, but no specific cases have been reported to the Department. At Toston in May, 1900, it was noticed that the terminal branchlets of *A. tridentata* had all been eaten off from a considerable number of plants.

SMALL-LEAVED CUDWEED.

(*Antennaria parvifolia* Nutt.)

The small, silky, curly-leaved cudweed, about 6 inches high, which grows abundantly in small patches on open hillside pastures, was eaten voluntarily and with considerable relish by a horse. Dr. S. P. Nelson[1] states that he fed three pounds of *A. luzuloides* to a sheep inside of 24 hours without causing any ill effect.

WILD CARAWAY.

(*Carum gairdneri* (Hook. & Arn.) A. Gray.)

A smooth, erect biennial, 1 to 4 feet high, with tuberous or turnip-shaped root, 3-parted leaves, and white flowers in flat-topped clusters. The plant is common in meadows and on hillsides throughout the State. The general distribution is from Washington and California to Idaho and Wyoming.

This species of wild caraway has been suspected of being poisonous to stock, but this is undoubtedly a mistake, for, according to our own observations, the roots under the erroneous name of wild parsnip are very frequently eaten in the raw state by boys, while according to Coulter, Rydberg, and others it is an article of food among the Indians. Coulter[2] states that "under the name of 'yamp' the root is a common article of food among the Indians of Idaho and Wyoming." He further states that "it is very palatable and nutritious, having somewhat the flavor of carrot."

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[1] U. S. Dept. Agr. B. A. I., Bul. 22, p. 13. 1898.

[2] Sixth Ann. Rept. U. S. Geol. Surv. of the Territories, p. 767. 1873.

REED CANARY GRASS.

(*Phalaris arundinacea* L.)

A perennial reed-like grass, 2 to 4 feet high, with broad flat leaves, 3 to 10 inches long, and flowering heads in large terminal panicles. This species is very common in wet meadows and sloughs throughout the State and is an important element of wild hay. It is found from Nova Scotia to British Columbia, south to New Jersey, Kentucky, Kansas, and Nevada. Prof. J. M. Coulter[1] quoting from Watson, says that "it is known as 'crazy grass' from its reputed injurious effect upon horses." Although coarse in texture it is considered harmless by the Minnesota agricultural station and by the Division of Agrostology of this Department. Our observations show that it is sometimes infested by ergot. This fungus is therefore most probably responsible for any ill effects which have been attributed to the grass.

WILD SUNFLOWER.

(*Balsamorhiza sagittata* Nutt.)

A perennial with thick balsamic roots, tufted, long, hairy root leaves, and simple, few-flowered, flowering stems 1 to 2 feet high, bearing usually solitary flower heads from 2 to 5 inches in diameter (Pl. XXXIV). The flowers appear in May and are among the most conspicuous of the season. This plant grows on dry hillsides in all parts of the State.

The dry rocky hillsides and shallow coulees, at an altitude of from about 5,000 to 7,000 feet, near Bozeman were yellow with the showy blossoms of this plant from the middle of May to nearly the middle of June. It is the most conspicuous of all the herbaceous plants at those altitudes, and is often seen in association with death camas, white lupine, and blue larkspur. The plant is generally distributed in the Rocky Mountains from Colorado through Montana to British Columbia. Close inspection of many growing plants during May and the first half of June in the Gallatin Valley failed to reveal any signs of its having been grazed upon, although another plant, the low milk vetch (*Orophaca caespitosa*)[2] which was named to us as a suspect, had been closely grazed in close proximity. A single leaf was fed out of hand to a stable horse four or five times, but the animal finally refused to eat any more, although it was strongly urged to do so. Even at first it ate none at all when purposely grazed with its nose close to the bunches. The wild sunflower is eaten on the range in other parts of the State by cattle and horses, and less extensively by sheep. On the summer ranges in the foothills and on the mountains, sheep eat

[1] Sixth Ann. Rept. U. S. Geol. Surv., vol. 6, p. 787. 1873. [2] See p. 148.

WILD SUNFLOWER (BALSAMORHIZA SAGITTATA).

the leaves of this plant with considerable relish, but at other times of the year they seldom touch it. The habits of horses and cattle in regard to it vary according to the individual animal, some eating it greedily and others passing it by. It is doubtful if its forage value is equal to that of some of the native legumes, but it occurs so abundantly throughout such a wide range that it must be considered of some economic importance. Large quantities of the plant were fed to horses and sheep without producing any bad effects, and animals were observed eating it freely on the ranges at different seasons of the year.

In two feeding experiments with rabbits 20 to 26 grams, respectively, out of 50 grams of the fresh leaves of the flowering plant offered were eaten without any apparent ill effect by two hungry 1½-pound rabbits within six hours. In another experiment 17 out of 50 grams was eaten. In every case the material was eaten very reluctantly, and the remainder of the 50 grams was refused in spite of hunger. No symptoms of poison were presented.

Our observations indicate that, as a rule, the leaves of the plant are not an acceptable food, and it is possible that if eaten in large quantities they might prove deleterious if not poisonous. All parts of the plant have a decidedly resinous taste. According to Rydberg, the seed, root, and young stalks are used for food by the Indians. A very similar plant, *Wyethia longicaulis*, is used for food by some of the California Indians, but in this case only the seed and the lower third of the tenderest leaves, together with a part of the flower stalks while they are still crisp and tender, are eaten. The root, which is far more resinous, is considered a valuable medicine.

WILD GERANIUM.

(*Geranium viscosissimum* Fisch. & Mey.)

A perennial herb 2 to 4 feet high, hairy throughout, with sharply serrate leaves and conspicuous purple flowers (Pl. III). The plant is common in valleys and on moist, shady hillsides in all parts of the State. The general distribution of this species is from California through Montana to the Saskatchewan.

On June 7, 19½ grams of the fresh leaves was offered to a young rabbit which had been deprived of its breakfast. It did not take to the ration readily, but about half of the quantity was eaten at 5 o'clock, when an accident put an end to further observations for the day. No ill effect was noted up to that time.

At Pullman, Wash.,[1] 3½ pounds of the fresh leaves of a similar species was fed in the course of a day to a sheep without causing any ill effect.

[1] U. S. Dept. Agr., B. A. I. Bul. 22, p. 14. 1898.

LOW MILK VETCH.

(*Orophaca caespitosa* (Nutt.) Britton.)

A low stemless, tufted, silky perennial, with 3-parted leaves crowded upon a short, branched, woody base, and numerous flowers which are exceeded by the leaves (Pl. XXXV). This species is locally abundant on dry plains and hillsides near Bozeman, Fort Benton, Fridley, Gardiner, Grafton, Billings, Lewiston, Baltic, Missoula, and Deerlodge. The general distribution of the species is from Nebraska and South Dakota to Montana and the Northwest Territory. It is abundant in the grazing land on the benches near Bozeman. The plant has been suspected of being one of the Montana locoweeds, but numerous closely grazed flowering plants were noticed in one field where the horses were not known to be affected by the loco disease. Immediately adjacent to these plants were numerous specimens of *Balsamorhiza sagittata* which had not been grazed upon at all, a fact that suggests that the vetch is the better fodder. Experiments made with both plants verify that belief.

Fifty grams of the perfectly fresh flowering and fruiting plant was offered to a hungry young rabbit two hours or so after gathering. All but the seed pods had been eaten after seven hours, and they, too, were all eaten next morning. No ill consequences resulted, and in fact the rabbit readily ate about 5 grams more of the plant the second day, thus showing that it was an acceptable food.

FALSE ESPARCET.

(*Astragalus bisulcatus* (Hook.) A. Gray.)

A rather stout perennial, 2 to 3 feet high, with numerous simple stems forming a large stool, long many-pinnate leaves, and narrow elongated racemes of showy purple flowers (Pl. XXXVI). The seed pods are characteristically two-grooved on the upper surface. It blossoms during May and June and the seeds ripen in July and August. This plant has attracted considerable attention in Montana on account of its abundance and its aggressive habits in certain localities. It is generally distributed over the State, and in many places grows so abundantly that it yields a fair crop of hay. Ordinarily it does not cover the ground completely, but grows in large stools which are separated by varying distances. A few large areas were observed where it covered the ground in the manner of a cultivated forage plant. Such areas are quite striking on account of the numerous bright violet-colored flowers. The plant is known to a number of stockmen by the name wild esparcet on account of its slight resemblance in general habit to the cultivated esparcet. It is at present cut for hay in only a small number of localities. When offered to

LOW MILK VETCH (OROPHACA CAESPITOSA).

FALSE ESPARCET (ASTRAGALUS BISULCATUS).

animals it is eaten greedily—sheep, cattle, and horses appearing to like it as well as the cultivated legumes. It was observed that it makes a good growth even in exceedingly dry soil. In one locality which had been less favored with rain, and where native grasses had been badly dried up, a field was found in which the plants stood at a height of 18 inches and covered the ground completely. It was in full bloom and in good condition to be cut for hay by June 10. As soon as the pods appear they are greedily eaten by sheep, and seem to be preferred to the other parts of the plant. All parts, however, are eaten in hay. Large quantities of it were fed to sheep and calves without any injurious effects, and it is certainly destined to be a valuable forage plant.

WHITE MILK VETCH.

(*Astragalus drummondii* Dougl.)

An erect perennial, 1 to 2 feet high, soft-hairy throughout, with numerous pinnately divided leaves, white flowers in long crowded racemes which blossom in June and July, and long slender greenish pods which droop upon the stems. The species grow abundantly upon prairies and hillsides in nearly all parts of the State, having been found in the season of 1900 at Livingston, Bozeman, Red Lodge, Bigtimber, Kalispell, Great Falls, Fort Benton, Lewistown, Missoula, and Deerlodge. The general distribution of this plant is from Colorado and Nebraska to the Saskatchewan.

No localities were found where this plant occupied the ground exclusively. It grows, however, in many areas where native hay is cut and constitutes an important element of such hay. It was abundant in pastures at Bozeman and at Livingston, but was not eaten by stock in the pre-flowering stage. Rabbits and also a stable horse refused to eat it out of hand in that condition, but a horse that had been staked out to graze and had perhaps somewhat accustomed itself to the plant ate a handful with apparent relish. One cow out of a large herd which was grazing amongst it voluntarily ate a large clump, but immediately afterwards passed many others without even nibbling at them. The herder stated that the cows ate the plants very rarely, but his remarks probably referred only to the period before blossoming. He had noted no ill effect from eating it.

A hungry rabbit ate in a period of seven hours only 6 out of 50 grams of the plant in the preflowering stage. No ill effect was noted. Another hungry rabbit that utterly refused to eat the leaves out of hand ate several bunches of the white flowers with great relish. The plant seems to be eaten more readily on the range by sheep than by cattle and horses. It is much liked in hay by all stock. Sheep seem to have a special fondness for the pods of the various native legumes

and it was frequently observed that bands of sheep were feeding exclusively upon the pods of *A. drummondii*. The pods when green have an agreeable flavor somewhat resembling that of the cultivated pea, and since they grow in large numbers on each plant and are of considerable size, it is an easy matter for sheep to fill themselves with this one kind of forage. On some sheep ranges this plant grows abundantly and it was noted that at the time when the pods were in best condition for eating they were entirely stripped from the plants, while the leaves and stems were left untouched.